DOCUMENT RESUME

ED 052 946

SE 011 183

TITLE	Aeronautical Science Course of Study.
INSTITUTION	California State Dept. of Education, Sacramento.; Southbay Union High School District, Redondo Beach, Calif.
SPONS AGENCY	Federal Aviation Administration, Washington, D.C.
PUB DATE	Oct 69
NOTE	252p.
AVAILABLE FROM	Superintendent of Documents, Government Printing Office, Washington, D.C. 20402 ($2.25)
EDRS PRICE	EDRS Price MF-$0.65 HC-$9.87
DESCRIPTORS	Aerospace Technology, *Aviation Technology, *Course Descriptions, Flight Training, *Instructional Materials, Resource Guides, *Science Education, Secondary School Science

ABSTRACT

This revision of "Aeronautical Science Course of Study for California High Schools," first issued in 1967, is designed by and for the use of teachers of high school aeronautical courses. It differs from other aeronautical instructional materials in its emphasis on inquiry, exploration, and open-ended experimentation. The eleven units may be used separately or as an entire course. The first nine units, designed for thirty-six weeks of classroom study, include: basic aeronautics, meteorology, navigation, FAA regulations, speed of sound, physiology of flight, man in space, history of aviation, and economic factors. The last two units deal with actual flight training. Lists of films and publications are provided. (RS)

AERONAUTICAL SCIENCE COURSE OF STUDY

ED052946

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
OFFICE OF EDUCATION
THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL OFFICE OF EDUCATION POSITION OR POLICY

OCTOBER 1969

SE 011 183

DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

ED052946

AERONAUTICAL SCIENCE COURSE OF STUDY

This document is a revision of the original publication entitled "Aeronautical Science Course of Study for California High Schools" and first published in a limited quantity in July 1967. Designed by and for the use of teachers of high school aeronautical courses and financed under an NDEA contract with the California State Department of Education.

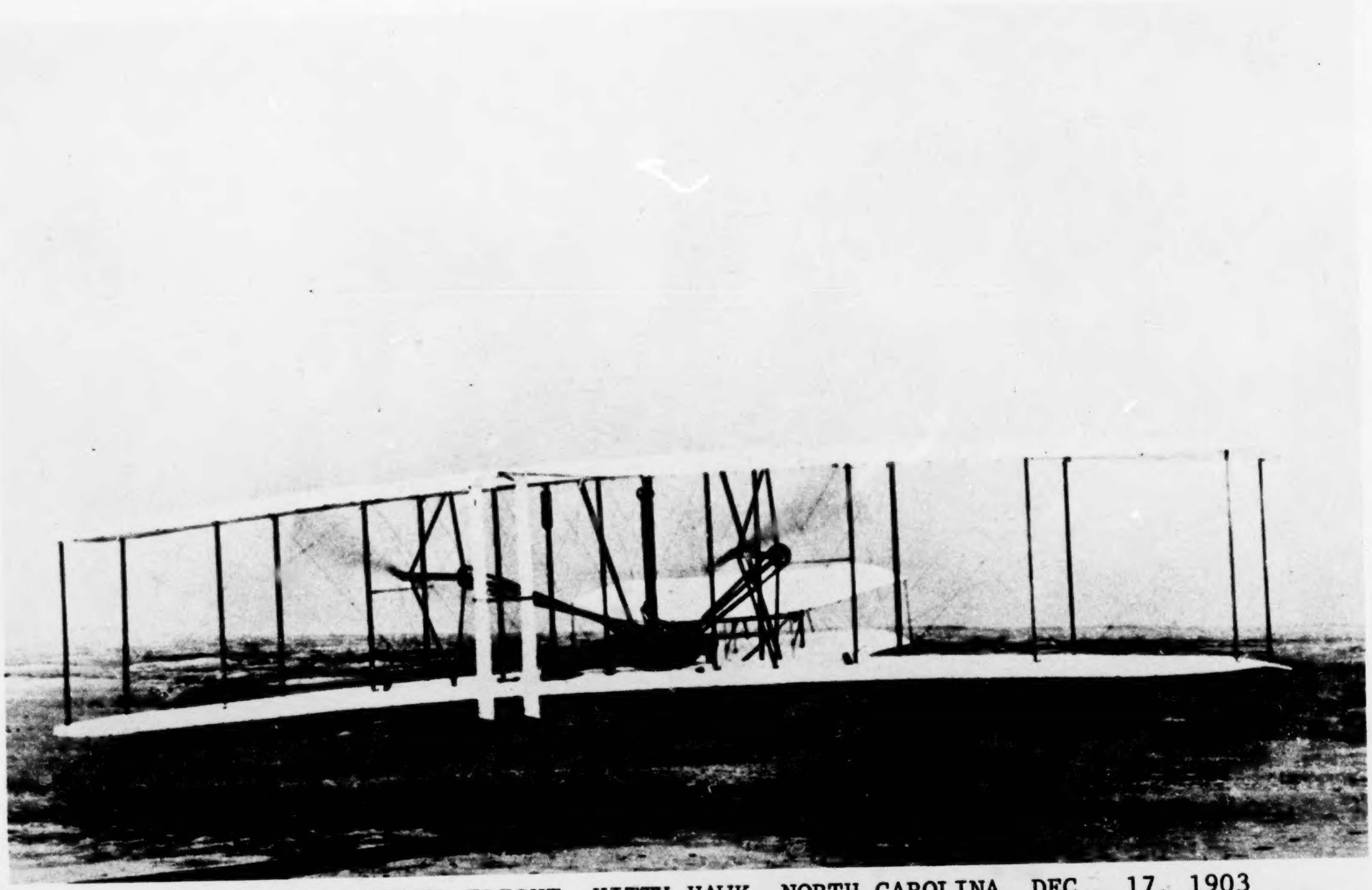
This revision includes: (1) aviation statistical data as of December 1968; (2) "Man in Space" unit projected through Apollo 20; and (3) an expanded section on sources of reference materials.

Produced Cooperatively by
The Redondo Union High School of the South Bay Union High School District,
Redondo Beach, California
and the California State Department of Education

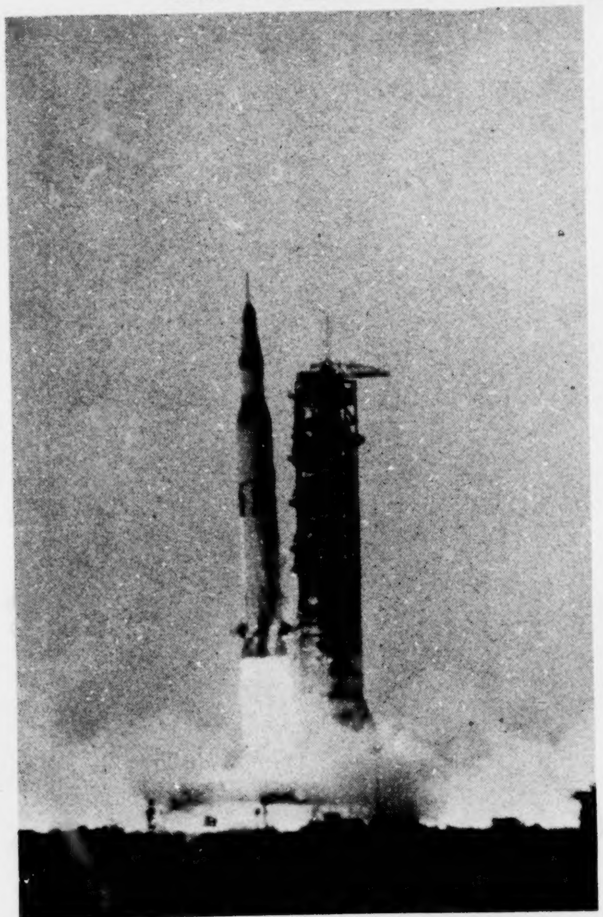
GA-20-10

The contents of this publication reflect the views of the Editorial Committee (See page xvii) which is responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policy of the Department of Transportation. This report does not constitute a standard.

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington, D.C. 20402 - Price $2.25

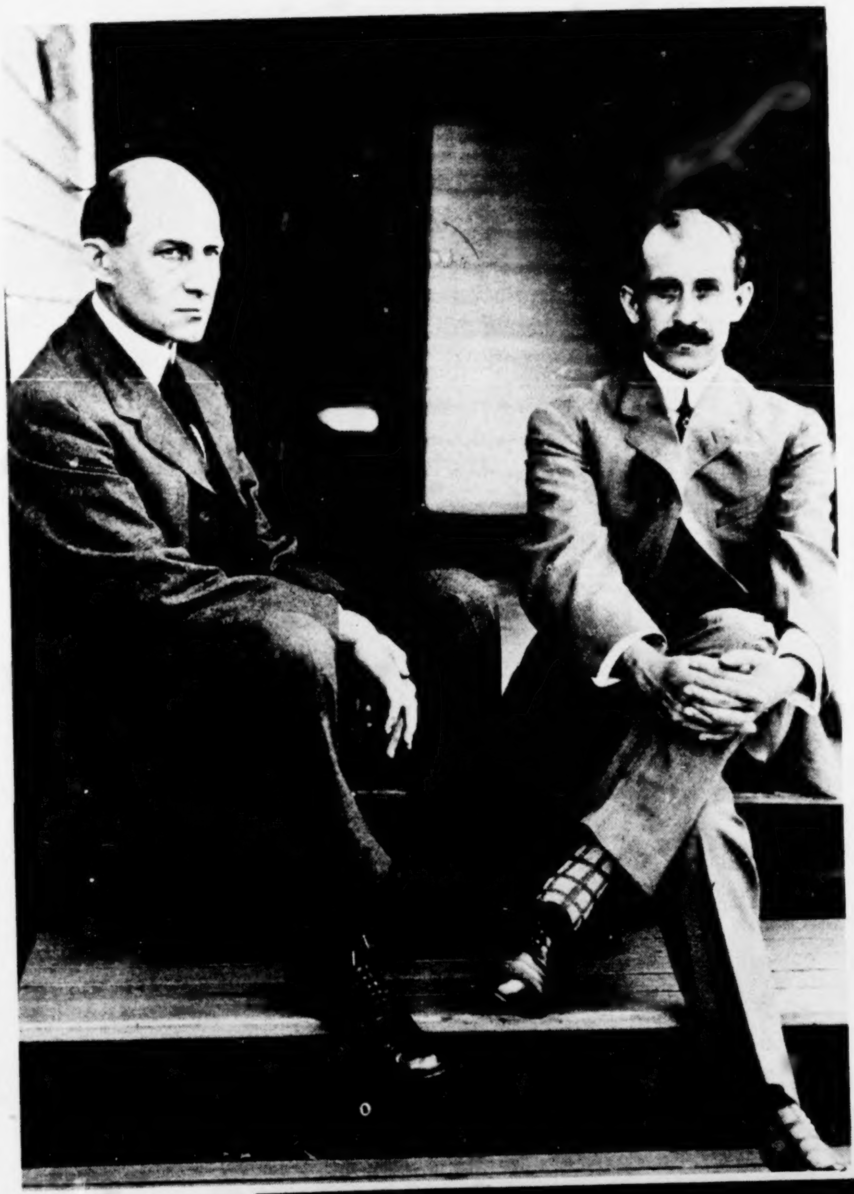


MAN'S FIRST POWERED FLIGHT, KITTY HAWK, NORTH CAROLINA, DEC., 17, 1903



APOLLO 11 AT LIFT OFF
CAPE KENNEDY, FLORIDA
JULY 16, 1969

ASTRONAUT ALDRIN AND LEM
TRANQUILITY BASE, MOON
JULY 20, 1969



Wilbur and Orville Wright

Astronauts Armstrong, Collins and Aldrin

DON H. CLAUSEN
REPRESENTATIVE IN CONGRESS
1ST DISTRICT, CALIFORNIA
"THE REDWOOD EMPIRE DISTRICT"

WASHINGTON OFFICE:
1035 HOUSE OFFICE BUILDING
WASHINGTON, D.C. 20515
PHONE: 225-3311
AREA CODE 202

DISTRICT OFFICE:
206 ROSENBERG BUILDING
306 MENDOCINO AVENUE
SANTA ROSA, CALIFORNIA 95401
PHONE: 545-8844

Congress of the United States
House of Representatives
Washington, D. C.

COMMITTEE:
PUBLIC WORKS

SUBCOMMITTEES:
RIVERS AND HARBORS
FLOOD CONTROL
ROADS
FEDERAL-AID HIGHWAYS
ECONOMIC DEVELOPMENT

COMMITTEE:
INTERIOR AND INSULAR AFFAIRS

SUBCOMMITTEES:
IRRIGATION AND RECLAMATION
NATIONAL PARKS AND RECREATION
PUBLIC LANDS

October 7, 1969

As one who has participated actively in both aviation and aviation education for more than two decades, I commend California educators at the local and state level for their imagination and initiative in developing this "Aeronautical Science Course of Study" for teachers.

As an elected representative of the First District of California and as President of the Congressional Flying Club, I recognize that there is growing national interest in capitalizing on the motivation, aviation and aerospace studies provide, for students as well as teachers. Thus, I see huge potential benefit in the sharing of this "Aeronautical Science Course of Study" material which the Department of Transportation, Federal Aviation Administration, Aviation Education staff members have made possible through this publishing effort.

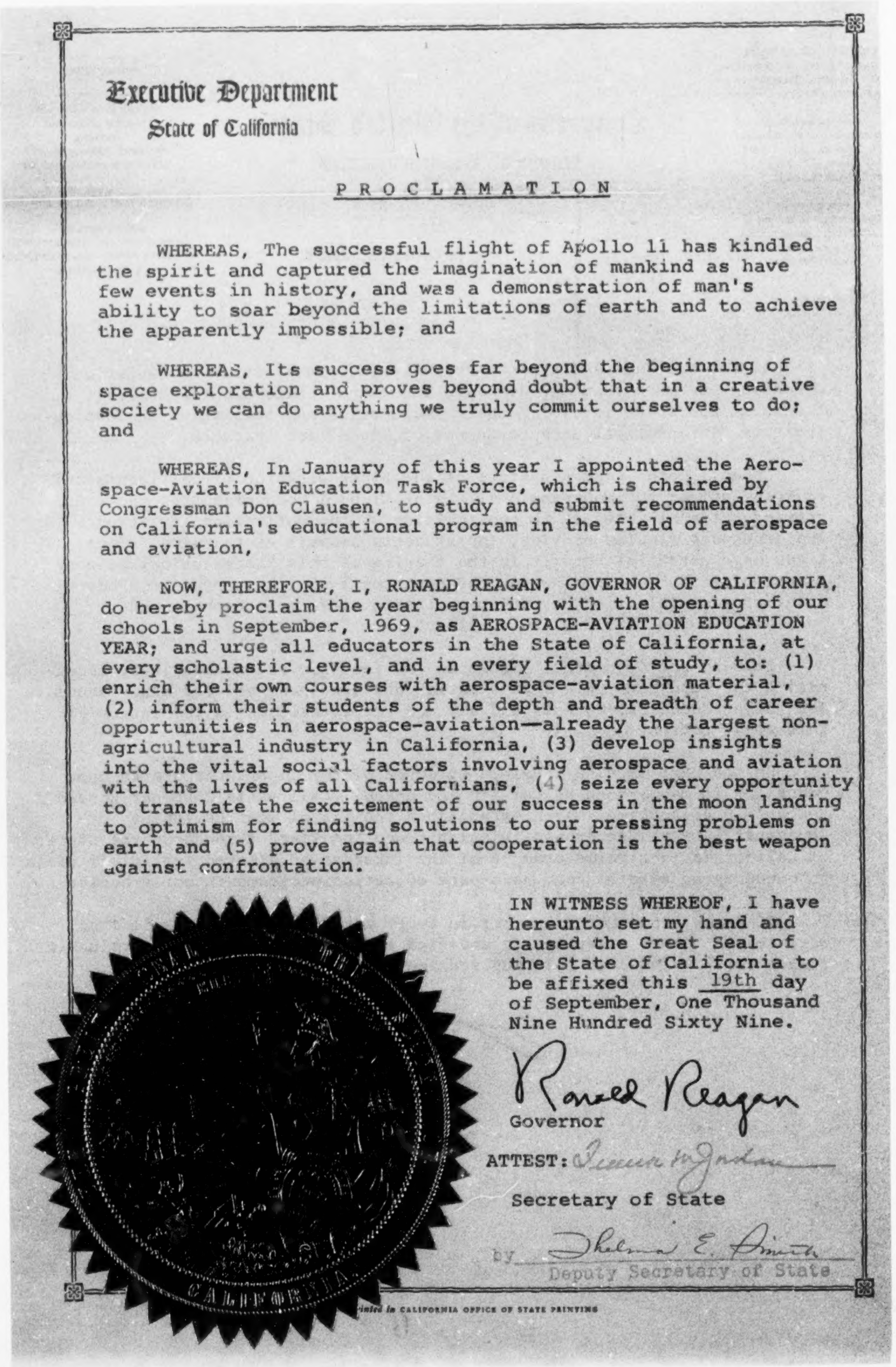
Leaders of government, education and industry are increasingly recognizing the important role that aviation and aerospace science study provides for youth, teachers, parents and all who are interested in the future of this great nation.

On the next page is tangible evidence of the importance placed upon education in man's conquest of air and space. California Governor Ronald Reagan's Proclamation, which establishes the school year beginning September 1969 as "Aerospace-Aviation Education Year" throughout the State of California is a prime example of the interest of elected public officials in encouraging aviation and aerospace education programs in our schools.

It is my hope that educators in every part of the nation will find ways to use either directly, or modified to suit local needs, the valuable suggestions included in this publication.

Don Clausen

Congressman Don Clausen
1st District of California
Chairman, Governor's Aerospace-Aviation
Education Task Force



Executive Department

State of California

PROCLAMATION

WHEREAS, The successful flight of Apollo 11 has kindled the spirit and captured the imagination of mankind as have few events in history, and was a demonstration of man's ability to soar beyond the limitations of earth and to achieve the apparently impossible; and

WHEREAS, Its success goes far beyond the beginning of space exploration and proves beyond doubt that in a creative society we can do anything we truly commit ourselves to do; and

WHEREAS, In January of this year I appointed the Aerospace-Aviation Education Task Force, which is chaired by Congressman Don Clausen, to study and submit recommendations on California's educational program in the field of aerospace and aviation,

NOW, THEREFORE, I, RONALD REAGAN, GOVERNOR OF CALIFORNIA, do hereby proclaim the year beginning with the opening of our schools in September, 1969, as AEROSPACE-AVIATION EDUCATION YEAR; and urge all educators in the State of California, at every scholastic level, and in every field of study, to: (1) enrich their own courses with aerospace-aviation material, (2) inform their students of the depth and breadth of career opportunities in aerospace-aviation—already the largest non-agricultural industry in California, (3) develop insights into the vital social factors involving aerospace and aviation with the lives of all Californians, (4) seize every opportunity to translate the excitement of our success in the moon landing to optimism for finding solutions to our pressing problems on earth and (5) prove again that cooperation is the best weapon against confrontation.

IN WITNESS WHEREOF, I have hereunto set my hand and caused the Great Seal of the State of California to be affixed this 19th day of September, One Thousand Nine Hundred Sixty Nine.

Ronald Reagan

Governor

ATTEST: Frank M. Jordan

Secretary of State

by Thelma E. Smith

Deputy Secretary of State

inted in CALIFORNIA OFFICE OF STATE PRINTING

Goals and Objectives of California Governor's Advisory Task Force on Aerospace-Aviation Education

1. To develop within the California public system of education, a planned and coordinated aerospace-aviation education program, which embodies all phases and all aspects of aviation, aeronautical, and space education.

2. To serve all levels--elementary, secondary, higher and adult education on a continuing basis in the State of California.

3. To serve the curriculum areas of general education, vocational education, adult, and in-service education.

4. To study, evaluate, and implement the findings of the California Aviation Education Advisory Commission established by the California State Department of Education in 1967.

5. To encourage and stimulate the formation of County Aerospace-Aviation Advisory Committees to better coordinate the implementation of programs through established and contemplated educational facilities and their administration.

6. To afford particular recognition and consideration to the recommendations of the Vocational Education Director and the aviation consultants to the Department of Education on how best to coordinate the integration of aerospace-aviation educational materials into the general and vocational education curricula--consistent with the demands and requirements of the jet and space ages.

7. To draw particular attention to the extraordinary advantages of including aircraft control manipulation as an integral part of the vocational and general education programs through the use of stationary classroom flight simulators in elementary and secondary schools, and through actual flight training programs in high schools and junior colleges where easy access to airports is available.

Excerpts from Address by Congressman Donald H. Clausen to the Aerospace-Education Task Force, Sacramento, California, June 16, 1969

Aviation and air transportation now play, and will continue to play, a dominant role in the movement of goods, services, and people throughout the State of California, the United States, and indeed, throughout the entire Western Hemisphere. As the jumbo jets, the SST, and other fixed and rotary-wing aircraft go into commercial use, world-wide air marketing programs will expand tremendously. In addition, there is growing interest in the future uses of STOL (short take-off & landing) and VTOL (vertical take-off & landing) aircraft to supplement the present air-carrier fleet. And business aviation and general aviation aircraft usage is expanding at fantastic rates of growth.

This, basically, is the direction in which we are moving when aerospace-aviation programs and objectives are viewed collectively.

But what are the more immediate benefits and advantages to be gained from a dynamic and future-oriented aerospace-aviation education program in the public schools of California?

What, specifically, is in it for the young people--the students of our State?

Over the years, successful aviation education programs have repeatedly demonstrated that they are, in fact, significant motivating factors in stimulating poor students to become honor students and inducing potential "drop-outs" to remain in school and complete their educations.

Therefore, and based on years of personal experience, I am convinced that aerospace-aviation education is not only an effective and viable "anti-drop-out tool"--but a highly motivating force that will provide the kind of a challenge that many young people desperately need early in life, especially during their school years.

I have proven to myself, during my 23 years of "experimenting" with this program of aerospace-aviation education that I can "capture the imagination" of any student from any home environment--by exposing him or her to the challenges of flight--be it in the classroom, the stationary Flight Simulator, or actual flight in an aircraft.

The cost? This is something that we must all be concerned about! Let me state categorically, however, that the implementation and insertion of this type of program into or associated with the established curriculum of our schools, will actually save money, when considered in conjunction with our total public sector budgets. Some sceptics might say, "How can you, Congressman Clausen, make this kind of statement?" Here again, permit me to relate some of my personal experiences.

During my service as a Member of the Board of Supervisors of Del Norte County for seven years, I reviewed, perused, and carefully scrutinized the annual budget of the various department heads. Among them, of course, were the budgets of the Judge of the Superior Court, the District Attorney's office, the Probation Office, the Juvenile Hall, the Sheriff, a Bar-"O"-Boys' Rehabilitation Camp, the Welfare Office, etc. After observing the large percentage of dollars of overall budget requested and required to finance the function of these offices, I decided to conduct research in the specific area of costs to our taxpayers for juvenile delinquency and probation problem, as well as minor and major criminal problems.

The cost factors revealed were, to say the least, shocking, and they prompted me to relate them to the high school principal, the Judge, the Supt. of Schools and Committee members of investigating Grand Juries. I found that each boy or girl committed to the Youth Authority or Dept. of Correction cost the taxpayers approximately $13,000, and those individuals committed to penal institutions, as convicted criminals, cost an average of $35,000. My candid comment to local officials at that time was, "Save one boy from the Youth Authority--you've bought one airplane or simulator--save one boy or girl from a life of crime, and you've paid for the entire program." Once exposed to these economic facts of life, these key community leaders and many previously sceptical parents could readily see the reasonableness and the rationale of my suggestion to "continue and broaden the exposure to the challenging program of aviation education in Del Norte High School." Therefore, I submit, we can better invest our tax dollars in the kind of innovative programs that I like to refer to as "preventive maintenance." Believe me, I can refer you to many parents who are willing to testify to the success of our efforts. Once our program was underway, an Assembly Committee on Education held hearings in Crescent City, California, for the purpose of evaluating our results. The testimony of some of these parents and students is available in the public hearing record.

Mine, of course, is but one experience. There are thousands of other examples, and one that bears repeating took place in the Richmond Unified School District. Here, a "flight experience program" was tested for students from the ghetto areas, and this experiment dramatically demonstrated and proved the motivational potential of the kind of program that will broaden their perspective through exposure to something new and challenging.

From this experience it was determined that learning performance was significantly improved for those students in the program who had been previously classified as "disciplinary problems." Thus, the value of this particular program was recognized not only by the students, and the school authorities, but more noteworthy, by the students' parents.

Thus, we see that the heart of the problem lies not so much in not having adequate or suitable aviation education programs--but rather, in the fact that we just don't have enough of these logical and constructive programs in existence.

We know, for instance, that 46 colleges and 77 high schools in California have some type of aviation education program, but from these figures, it is obvious that there are far too many areas where such programs just don't exist at all. This, then is the challenge and the opportunity. The time has come for all Californians, all Americans, and in particular, our educational institutions to broaden their perspective to eliminate "tunnel vision"--to seek broader horizons in this, our jet and space age.

The challenge of change, in our everyday living, demands that we commit ourselves to this worthy task.

We can, as dedicated and creative people, recapture the American dream--through aviation.

We can rekindle the spark of hope and faith in America--through aviation.

We can stimulate, motivate, and accelerate the learning process--through aviation.

We can broaden the horizons--we can broaden the perspective of individuals--through aviation.

We can open up "opportunities unlimited" for this generation and future generations--through aviation.

We can "Revitalize Rural America," and "Build Countryside, USA"--through aviation.

We can provide relief from the over-crowded "pressure cookers"--the "high rise ghettos"--the "concrete jungles" of urban metropolitan areas--through aviation.

We can better coordinate the movement of people, goods, and services--through aviation.

We can improve the "environment for future living"--through aviation.

Governor Reagan, we, the members of your Aerospace-Aviation Education Task Force, are deeply grateful to you for "launching" this timely space-age education proposal, just one day before the arrival of the Apollo 10 astronauts--Stafford, Young, and Cernan--here in California.

In six months, we hope to have before you the best recommendation California's aviation "brain power" can formulate. Like you, "we want to make the best--better."

TABLE OF CONTENTS

	Page
PREFACE	xiii
FOREWORD	xv
ACKNOWLEDGMENTS	xvii
EDITORIAL RATIONALE	xix

UNIT	SUGGESTED TIME (weeks)	Page
BASIC AERONAUTICS	8	1
METEOROLOGY	6	31
NAVIGATION	8	51
FEDERAL AVIATION REGULATIONS	3	71
SPEED OF SOUND	2	91
PHYSIOLOGY OF FLIGHT	2	97
MAN IN SPACE	2	117
HISTORY OF AVIATION	2	155
ECONOMIC FACTORS OF AVIATION & SPACE	3	165
FLIGHT INDOCTRINATION		191
FLIGHT TRAINING		207
LIST OF GENERAL INTEREST FILMS, FILM PRODUCERS AND FILM DISTRIBUTORS		229
READING LIST		237

APPENDIX:

A. AERONAUTICAL SCIENCE ACTIVITIES AT REDONDO UNION HIGH SCHOOL	247
B. FIELD TRIPS AND CAREER OPPORTUNITIES	251
C. APPROXIMATE COSTS FOR A BASIC AND EXPANDED CLASS	253
PUBLICATION ORDER FORM	255
FAA SUBSCRIPTION SERVICES	257

PREFACE

In 1960, an instructional guide for the high schools in California, entitled Aviation Education and the Space Age, was published by the State Department of Education. Ever since then the Department has received requests for a high school aviation or aeronautical science course of study similar to those now used by the 25 California high schools that offer instruction in aeroscience. No action was taken immediately since there is available a wide variety and an ample supply of information for teachers who are interested in demonstrating the implications of aviation and space to their students. For example, U. S. Government sources include the Department of Transportation's Federal Aviation Administration, which makes available an abundance of materials, manuals, and guides for pre-pilot and technical instruction, and the National Aeronautics and Space Administration, which provides excellent guides on vocational and technical training in aeronautics as well as materials on the space programs. Nevertheless, aerospace educators have continued to insist that a great need exists for a high school aeronautical course of study that is science-based, with emphasis on inquiry, exploration, and open-ended experiments.

The California Department of Education concurred that a course of study in aeronautical science* for California high schools is indeed needed. Some reasons are: (1) the demands for qualified personnel in all branches of aviation and space have exceeded the highest previous estimates; (2) the increasing interest of youth in aviation and space careers has prompted many schools to offer aeronautical courses (high schools and junior colleges that offered no such curricula five years ago now have hundreds of students enrolled in courses that are designed to prepare them for aeronautical careers); (3) modern educators are becoming increasingly aware that the interest of youth in aeronautics can be utilized to motivate and direct learning in the classroom; (4) the safety record of aviation may be improved substantially through scientific instructions to prospective pilots; and (5) many California high schools offering aviation courses have made only nominal reference to the scientific principles that are basic to aeronautics.

It became increasingly evident that high school aeronautical courses needed to implement the method of "learning by discovery" as they taught basic aerospace information. With the rising number of requests for guidance in establishing such courses, the State Department of Education in early 1967 called upon selected members of its Aerospace Education Advisory Committee to develop a course outline for Aeronautical Sciences. The present volume is a result of that work. It was revised in late 1968 following extensive evaluation and use throughout the State. In August 1969, the Man in Space unit was revised to reflect the Apollo 11 and subsequent Apollo missions. It is being printed and distributed with the assistance of the Federal Aviation Administration so that it can be made available to schools throughout the United States who wish to establish similar courses.

---

*In this aeronautical science guide, both aviation and space studies have been included.

The course outline is divided into eleven units. These may be used singly or as the basis for an entire course, and may be organized into any order the instructor desires. The editorial committee selected those texts and sources that, in their opinion, were leaders in the field and that best suited this particular course outline. The sources are by no means all-inclusive, but are intended to save the instructor a time-consuming search through the massive amount of material available on the many subjects presented here.

This course guide was originally completed in June 1967 and since then has been field tested and reviewed by appropriate aerospace government and scientific organizations and individuals for accuracy. The "Man in Space" unit was updated through July 1969, which includes the mission of Apollo 11, plans for Apollo flights 12 through 20, the handling of precious cargo from the moon, and planetary probes from 1969 into the 1980's.

It is hoped that teachers will incorporate this guide into a looseleaf manual that they can keep up-to-date and supplement with materials and experiments. Any recommendations for later revisions should be forwarded to The California State Department of Education, 721 Capitol Mall, Sacramento, California 95814, Attention: Mr. W. Earl Sams.

FOREWORD

Educational programs in California public schools are constantly redesigned to meet current as well as anticipated needs. The State Department of Education has an ongoing program to provide guidelines and materials to assist schools toward that end. This Course Outline is part of that program.

Man's conquest of the air and space should be recognized more fully by the schools of California -- the state with the greatest aeronautics potential in the world. It is my hope that California public schools, as well as other schools throughout the country, will utilize the material in this course of study. By so doing, they will help to prepare students to meet the existing and future problems associated with aviation and space.

Max Rafferty

MAX RAFFERTY
Superintendent of Public Instruction

ACKNOWLEDGMENTS

The Department of Education is indebted to the South Bay Union High School District, the Redondo Union High School, and Mr. Ted Misenhimer, Aeronautics Instructor, for directing the work of the Editorial Committee and for completing the publication.

Acknowledgment is made also to the following members of the Editorial Committee for their contributions:

T. G. Misenhimer
Aeronautical Science Instructor
Redondo Union High School
631 Vincent Park
Redondo Beach, California 90277

David P. McLaren
Secondary Science Supervisor
Los Angeles City Schools
450 North Grand Avenue
Los Angeles, California 90012

Miss Harriett Porch
Research Staff
The RAND Corporation
1700 Main Street
Santa Monica, California 90406

Ralph Scharch
R. W. Scharch Flight and Ground School
2761 Hollywood Way
Burbank, California 91503

Mrs. Inez W. Woods
Teacher
Los Angeles City Schools
1546 Rodeo Road
Arcadia, California

Gratitude is expressed also to the following persons who assisted in the organization and content of this aeronautical science course of study:

ACKNOWLEDGMENTS (Cont'd)

Stewart M. Angle
Mt. San Antonio College
1100 North Grand Avenue
Walnut, California 91789

Hal Corbett
Avion Air Flight School
2946 Fairchild Apron
Torrance Airport
Torrance, California 90505

Howard Critchell
Bates Foundation for
Aeronautical Education
Harvey Mudd College
Claremont, California 91711

Mike Donahoe
National Aeronautics and Space
Administration
Educational Programs
4800 Oak Grove Avenue
Pasadena, California 91103

Alan L. Hoffman
Cessna Aircraft Company
Wichita, Kansas 67200
(formerly with Aviation High School
Redondo Beach, California)

Eugene S. Kropf
Federal Aviation Administration
5651 West Manchester Avenue
P. O. Box 90007, Airport Station
Los Angeles, California 90009

Marshall Lakin
San Bernardino Valley College
701 South Mt. Vernon Avenue
San Bernardino, California 92403

Mervin K. Strickler, Jr.
Special Assistant for Aviation Education
Federal Aviation Administration
800 Independence Avenue S.W.
Washington, D. C. 20590

Robert F. O'Neil
Special Assistant for Aviation Education
Federal Aviation Administration
800 Independence Avenue S.W.
Washington, D. C. 20590

Lloyd P. LaPlant
Grossmont High School
P. O. Box 43
Grossmont, California 92030

Jeffrey L. Lee
Art Student
Redondo Union High School
631 Vincent Park
Redondo Beach, California 90277

John McBeath
Novato High School
625 Arthur Street
Novato, California 94927

Jack E. Mulkey
Coalinga Junior College
300 Cherry Lane
Coalinga, California 93210

Warren Susan
Laney College
1001 Third Avenue
Oakland, California 94606

Walter C. Van Emon
Novato High School
625 Arthur Street
Novato, California 94927

Albert D. Vance
Coalinga College
300 Cherry Lane
Coalinga, California 93210
(formerly with Glendale College)

Howard H. Winter
Elk Grove High School
9800 Elk Grove-Florin
Elk Grove, California 95624

W. Earl Sams, Consultant
Bu. of Elem. and Secondary Ed.
Calif. State Dept. of Ed.
721 Capitol Mall
Sacramento, Calif. 95814

(Mrs.) Pat Jackson, Editorial Ass't.
Aviation Education Staff, FAA
Washington, D. C. 20590

EDITORIAL RATIONALE

As society evolves, the needs of man change. If schools are to aid in fulfilling those needs, then their curricula must be flexible. Fifty years ago Greek was part of the classical course in secondary schools; today, driver education seems more pertinent; and it is not too far-fetched to believe that aeronautical training could soon be mandatory.

Cultural lag is defined as the time between discovery and acceptance. Once a President ordered a bathtub removed from the White House because it was "indecent"; automobiles often were called "contraptions of the devil". Today, there still lingers some reluctance to include aeronautical science in the secondary curriculum.

Why should such a course be offered? What are the advantages of teaching aeronautical science in high school?

If the purpose of schools is really to educate, students first must learn how to study, how to read of their own volition, and how to search and research beyond minimum assignments. Few subjects arouse this burning interest in students. Aeronautical science does! The same science student who experiences Bernoulli's theorem for only a few months until he has passed his final examination will never forget that theorem if, in an aeronautical science course, he has seen its application in creating lift and making an airplane fly.

How can an educator expect a secondary mathematics student to care how many oranges he can buy for a dollar? That same student, in aeronautical science, will enjoy solving complex mathematical problems in navigation. Why? The answer, of course, is motivation. Volumes have been written on it, but a disproportionately small amount of it is generated in the classroom. Aeronautical Science has built-in motivation that naturally involved good study habits simultaneously with the attainment of knowledge. But what kind of knowledge?

In terms of the standard curriculum, aeronautical science offers much in earth science and even more in physical science. Laws of temperature, pressure, motion, density, action of gases, light, images, sound, magnetism, and gyroscopes are approached with enthusiasm.

Mathematics is the essence of navigation. And in the weight and balance problems of loading an airplane, a student works with center of gravity, levers, and moments. Science and mathematics are intricately interwoven into a subject with tremendous student interest.

Aeronautical science strengthens the social studies concepts of geography; maps and globes are vital to the understanding that the student craves. And he reviews solid geometry in projections, great circle routes, and rhumb lines. The student realizes that great circle routes bring the farthest point on the globe, be it friendly or alien, within reach of a few hours by air. The history of aviation is largely the history of man's accomplishments from da Vinci to the present.

In the area of language skills, the astronautical science student meets and masters many terms that will be part of the popular vocabulary a few years hence. Such terms as "apogee" and "perigee" are more than mere words to increase his vocabulary -- they are concepts. A student's oral skills are sharpened as he perfects his pronunciation for clear radio transmission.

In short, aeronautical science is in itself a course rich in learning and it is a highly motivating course which reinforces the learnings in many other subject fields.

The Education Code of the State of California, Section 8401, says, in part: "The Department of Education shall aid and assist local school districts in the development and conduct of a program of aviation education. The Division of Aeronautics may aid and assist in the selection of airports and pilots used by the local school districts in flight indoctrination and instruction." Sections 8402, 8404, and 25519 also pertain to the inclusion of aeronautical training in the public schools of California.

Why should the State Department of Education encourage aeronautical training? One reason might be that the Bureau of Labor statistics indicates that more people are employed in the aerospace industry than in any field other than agriculture in the United States, and California has the lion's share. More than one-third of all missile and space workers in the United States are employed in California; the giants among the aircraft manufacturers line the state's coastline. We believe the public schools have the responsibility to prepare students for participation in the industry that will employ a great percentage of them.

We believe that the public schools have a further responsibility in the area of national security. At present, there is an acute shortage of trained mechanics, expert electronic (avionics) repairmen, and pilots, both civilian and military. Students should acquire an elementary knowledge of aeronautics, of the military uses of aviation both for offense and for defense, and thus realize the extreme necessity of air power in national security.

The public schools should teach students the importance of aeronautics and astronautics to the economic well-being of the nation and, more particularly, to the financial strength of California. The public schools should explore with students the multitudinous career opportunities in aerospace both military and civilian.

We believe there is no course offered at high school level that can match or approach aeronautical science, either for the incentive it holds for higher education to the college-capable student or for the job placement opportunities it explores with the student who goes to work immediately from high school.

This, then, is the rationale, the reason for being, of an aeronautical science course for California high schools. The content in this course of study is rich and rewarding. Its beneficial effects on students are great and lasting.

T. G. Misenhimer
David McLaren
Harriett Porch
Ralph Scharch
Inez Woods

INTRODUCTION

Certainly Daedalus and his son Icarus must have been students of aeronautics, for they were among the first legendary men to fly. They fashioned wings from feathers and wax. Attaching them to their arms, they were able to fly with a vigorous flapping motion. Of course, this was a myth. But, as the legend continues, Icarus became a statistic when he experienced structural failure while flying too close to the sun where the heat melted the wax on his wings. Should we also consider this the first "heat barrier?"

Even the student who has not studied Aeronautical Science knows that Orville and Wilbur Wright were the first to fly a heavier-than-air powered craft, and that Icarus' high flying would have resulted in a cooler atmosphere. And, even though Leonardo da Vinci said, "A bird is an instrument working according to mathematical law, which instrument it is within the capacity of man to reproduce with all its movements," the youngster of today knows it is virtually impossible!

Every student coming to our secondary schools today has a certain built-in knowledge and awareness concerning all that is about him. He is the possessor of so much knowledge that da Vinci, with all of his brilliance, would have stood in amazement at what a 15-year-old knows.

Herein lies the challenge! This 15-year-old of today needs to build upon that which he experiences day by day. The technological age surrounding him demands his understanding and knowledge. We are constantly being encouraged to motivate and challenge our students. What better way than through the media of the 20th Century subject, Aeronautical Science.

Therefore, we start at the beginning, the Basics of Aeronautics.

TO THE TEACHER

Included in this unit of the Course of Study are:

1. The earth's atmosphere
2. Theories of flight
3. Forces during flight
4. Aircraft structure
5. Stability
6. Control during flight
7. Flight instruments
8. Reciprocating engines
9. Reaction engines
10. Helicopters

To any serious student of the subject, the basics of aeronautics should be well understood before pursuing the other areas of study.

Undoubtedly, the areas listed above do not cover all that would be required of an Aeronautical Engineer. However, with the items as listed, and their references, an individual could very well prepare himself in this area for the private and commercial license. Moreover, and possibly what is more important, a new approach to the study of Physics and Physical Sciences is evidenced here and in other units to follow.

The attempt has been made to relate most features of this study to a scientific principle, demonstration or experiment. The endeavor is not to supplant the study of Physics or any of the Physical Sciences, but to motivate, through this captivating vehicle, Aeronautical Science.

The teacher will find it advisable at times to enlist the aid of the Physics teacher in such areas as demonstration equipment and possibly in the capacity of a team teacher.

Following the outline of Basic Aeronautics is a description of the basic Laws of Motion, several pages of experiments and demonstrations related to this unit, and references, film list and aids.

This unit can be one of the most rewarding to the student and teacher because both will continually be discovering new facts. Use of the films as listed will augment lecture, exercise and demonstration.

As the course progresses, many students will become interested in flying, if they have not already done so. Therefore, a very particular aim in this first unit of study is to prepare all students well enough so that those who eventually go on into flying will have a thorough knowledge of the basics.

UNIT OUTLINE

I. The Earth's Atmosphere	Misenhimer - Basic Aerodynamics Unit
A. Physical properties.	
1. Molecules.	
a. Brownian movement.	Van Sickle, pp. 4-5.
b. Diffusion	See Precipitation Chamber, Fig. 1.
2. Composition of the atmosphere.	Van Deventer, pp. 41-45.
3. Density. a. Archimedes' Principle. b. Effect of humidity.	Van Deventer, pp. 41-44. Every object in the atmosphere is buoyed up by a force equal to the weight of the air it displaces. See Fig.2.
4. Pressure. a. Torricelli's experiment.	Van Deventer, Experiment, p.45.
b. Pascal's Principle Example: Uniform pattern of spray from the entire length of a perforated hose.	"Pressure applied anywhere on a confined fluid is transmitted undiminished in every direction. The force thus exerted by the confined fluid acts at right angle to every portion of the surface of the container, and is equal upon equal areas."
c. Archimedes' Principle.	"The buoyant force which a fluid exerts on a body placed in it is equal to the weight of the fluid the body displaces."
d. Atmospheric pressure. e. Weight of air.	Van Sickle, pp. 5-6, 237. See Figure 3.
B. Phenomena and structure of the atmosphere.	Van Sickle, p. 9 (Chart)
II. Theories of Flight	FAA motion picture - "How Airplanes Fly"
A. Daniel Bernoulli's Principle.	Van Sickle, p. 46. Van Deventer, pp. 51-55. See Figures 4, 5, 6, 7, 8, 9.
B. Incompressible flow equation. (dynamic pressure)	Van Deventer, p. 53.
C. Stream tube.	Tower, p. 13.

D. Venturi tube.	Van Deventer, p. 51.
1. Definition.	Tower, p. 14
2. Indicate relationship between Venturi tube and airfoil.	
E. Air Foil.	Tower, p. 18.
1. Nomenclature.	Van Deventer, pp. 53-55, 115-120.
a. Chord.	
b. Camber.	Van Sickle, pp. 44-45.
c. Leading and trailing edge.	
2. Top action.	Tower, p. 15. Van Deventer, p.55, Fig. 4. See Figures 10, 11, and 12.
3. Skiing action. (angle of attack)	Tower, pp. 16-17.
a. Newton's Third Law	"For every action there is an opposite and equal reaction."
b. Deflection.	Van Sickle, p. 48. Van Deventer, p. 55.
c. Percent of total lift.	See Figure 12.
F. Streamlining.	Van Deventer, pp. 64-65. Van Sickle, pp. 46-47, 55.
G. Factors affecting lift.	Van Deventer, pp. 55-56.
1. Speed.	Van Sickle, pp. 48, 296.
2. Density.	Tower, p. 17.
3. Angle of attack.	
H. Relative air flow.	Van Deventer, p. 55.
1. Angle of attack.	
2. Angle of incidence.	"A fixed angle between the plane of the wind chord and the line of thrust or any other longitudinal line which is level when the fuselage is level longitudinally. The angle of incidence is always a fixed angle except in a few rare cases where variable incidence wings have been tried.
I. Resultant force.	Van Deventer, p. 58, Fig. 11.
1. Lift.	
2. Drag.	FAA's "Private Pilot's Handbook of Aeronautical Knowledge," AC-61-23
3. Resultant.	
J. Stall.	Tower, p. 17.
1. Burbling.	Van Deventer, pp. 75-77.

2. At landing.	
3. Stall warnings.	
4. Warning devices.	
K. Aspect ratio.	Van Deventer, pp. 60-63.
1. Tip vortex.	Van Sickle, p. 54.
2. Total wing drag.	Van Sickle, p. 53.
3. Examples of high aspect ratio.	
a. Gliders.	
b. U-2.	
III. Forces During Flight	Tower, pp. 20-23.
	Van Sickle, pp. 41-42.
A. Lift.	Van Deventer, p. 70.
	Use Wind Tunnel to demonstrate, see Figure 12.
B. Drag.	
1. Profile	
2. Parasite.	Van Deventer, p. 59.
3. Wing.	
4. Induced.	
C. Gravity.	
D. Thrust.	See Figure 13.
IV. Aircraft Structure	Tower, p. 24.
A. Parts of an aircraft.	See Figure 14 for nomenclature.
1. Fuselage	
2. Wings	Van Deventer, pp. 138-140.
3. Empenage.	Van Deventer, p. 145.
4. Powerplant.	
a. Reciprocating.	
1. Opposed.	
2. Inline.	
3. Vee.	
4. Radial.	
5. Rotary.	
b. Reaction.	
5. Landing gear.	Van Deventer, pp. 146-157.
a. Conventional.	Van Sickle, pp. 99-105.
b. Tricycle.	Above and Beyond, Vol. 1
c. Cantilever.	
d. Spring steel.	
e. Retractable.	
f. Fixed.	
g. Crosswind.	
h. Shock struts.	
i. Brakes.	
j. Floats and hulls.	

- B. Stresses.
  - 1. Types.
    - a. Tension.
    - b. Compression.
    - c. Shear.
    - d. Bending.
  - 2. Strain.
  - 3. Modules of elasticity.
  - 4. Load factor.

Tower, pp. 25-28.
Van Deventer, p. 136.
Van Sickle, p. 87.

See Basic Laws of Motion at the end of this unit outline, pp. 14-15.

Van Deventer, p. 137.
Van Sickle, pp. 44, 85-86.

V. Stability

- A. Axis of airplane.
  - 1. Roll (longitudinal); control surface-aileron.
  - 2. Pitch (lateral); control surface-elevator.
  - 3. Yaw (vertical); control surface-rudder.
  - 4. Methods of building in stability.
    - a. Dihedral.
    - b. Sweepback.
    - c. Keel effect.
    - d. Vertical fin.
    - e. Position of center of gravity in relation to center of lift.
    - f. Weathervane effect.

Tower, p. 60.

Van Deventer, pp. 85-92.

- B. Degrees of stability.
  - 1. Positive static stability.
  - 2. Negative static stability.
  - 3. Neutral static stability.
  - 4. Dynamic stability.
  - 5. Dynamic instability.

Van Sickle, pp. 62-66.
Tower, pp. 60-66.
Van Deventer, pp. 81-83.
See Figure 15.

- C. Longitudinal stability.
  - 1. Minus lift tendency.
  - 2. Center of lift, center of gravity relationship.

Van Deventer, p. 89.

- D. Lateral stability.
  - 1. Dihedral.
  - 2. Keel effect.
  - 3. Sweepback.

Van Deventer, p. 89.
Van Sickle, p. 64.

- E. Directional stability.
  - 1. Sweepback.
  - 2. Vertical fin.
  - 3. Weathervane effect.
  - 4. Area fore and aft of center of gravity.

Van Deventer, p. 91.
See Figure 16.

F. Torque.
  1. Theories
    a. Gyroscopic.

Precessing force that is set up at right angles to rotating propeller. See Figures 17 & 18.

    b. Spiraling slipstream.

The spiraling wash of the propeller impacts the vertical fin at a slight angle, thus forcing the tail to the right and yawing the nose to the left.

    c. Reactive force.

Newton's Law of Action - Reaction: Air moved counterclockwise by propeller is countered by a left rotating force on the aircraft's longitudinal axis.

  2. Correcting for torque.
    a. Wash in - wash out; offset fin.
    b. Contra-rotating propellers.
    c. Reaction engines.

Above and Beyond, Vol. 6
Rudder trim.

  3. Torque during:
    a. Takeoff.
    b. Climb.
    c. Cruise.

VI. Control During Flight

Van Deventer, pp. 92-98.

A. Basic maneuvers.
  1. Bank and turn.
  2. Climb and dive.

Use stick model with controls and control surfaces to demonstrate. Also, use Link Trainer.

B. Basic cockpit flight controls.
  1. Rudder pedals.
  2. Stick or wheel.
  3. Throttle.

Beech Aircraft Corp. - motion picture "Discover Flying"

C. Basic control surfaces.
  1. Rudder
  2. Ailerons.
  3. Elevators.
  4. Flaps, types:
    a. Simple.
    b. Slot.
    c. Split.
    d. Fowler
    e. Zap.

Van Deventer, p. 64.
Van Deventer, p. 66 for comparative effectiveness.

D. Unconventional controls.
  1. Elevons - F4D.
  2. Ruddervators - Bonanza.

Above and Beyond, Vol. 1
Above and Beyond, Vol. 1

3. Spoilers - P61.	Above and Beyond, Vols 1, 2, 3.
4. Stabilator (slab tail).	Above and Beyond, Vol. 4.
E. Auxiliary control surfaces.	
1. Trim tabs.	Van Deventer, p. 95.
2. Balanced controls.	Van Deventer, pp. 95-96 Above and Beyond, Vol. 7
VII. Flight Instruments	Use cutaway instruments to show parts; use Link Trainer to demonstrate flight instruments. Also refer to Exhibit 1.
A. Pitot-static group.	Van Deventer, p. 220, Ch.10.
1. Airspeed indicator.	Van Sickle, p. 185, Ch.6.
2. Altimeter.	
3. Rate of climb.	See Figure 19.
B. Pitot-static tube.	
1. Impact pressure .	
2. Static pressure.	
3. Baffle plate.	
4. Riser.	
5. Heating elements.	
C. Airspeed indicator.	Above and Beyond, Vols.1,7,9.
1. Differential pressure.	
2. Hollow diaphragm.	
3. Errors.	
a. Installation.	
b. Compressibility.	
c. Air density.	
4. Types of airspeed.	
a. IAS.	
b. CAS.	
c. TAS.	
5. Dial markings.	Van Deventer, p. 224.
D. Sensitive altimeter.	Above and Beyond, Vol.1
1. Simple aneroid barometer.	
2. Altimeter setting.	
3. Errors.	
4. Pressure altitude.	
E. Rate of climb. (Vertical Speed Indicator)	
1. Differential pressure.	Above and Beyond, Vol.13
2. Calibrated leak.	
F. Magnetic compass.	Van Sickle, p. 556.
1. Details of construction.	Van Deventer, pp. 228-229.
2. Principle of operation.	Tower, pp. 148-155.
3. Magnetic variation.	
a. Isogonic lines.	
b. Agonic line.	
4. Compass deviation.	Van Sickle, p. 557.

G. Gyroscopic instruments.	Van Deventer, p. 230.
1. The gyroscope.	
a. Rigidity. b. Precession.	See Figure 17, and "Gyroscopic Motion", Figure 18.
2. Bank and turn.	
a. Gyro rotor.	
b. Vacuum generator.	
1. Engine pump.	
2. Venturi tube.	
c. Response to turns.	
d. Damping.	
e. Inclinometer.	
3. Directional gyro.	Van Deventer, p. 233.
a. Operation.	
b. Not north-seeking.	
c. Caging.	
d. Setting the directional gyro.	
4. Attitude indicator.	
a. Other names.	
b. Methods of driving gyro.	Van Sickle, p. 190.
H. Loads.	Tower, p. 24.
1. Stresses	Van Deventer, p. 136.
a. Compression.	
b. Tension.	
c. Bending.	
d. Torsions.	
2. External loads.	
a. During flight.	Van Sickle, p. 82.
(1) Wing loading.	
(2) Maneuvering loads.	
(3) Gusts.	
b. Dynamic loads.	
(1) Flutter.	
(2) Divergence.	
(3) Aileron reversal.	
c. Load factor.	
(1) g force.	Van Sickle, pp. 226,325,318.
(2) Flexibility.	
VIII. Reciprocating Engines	Van Deventer, p. 169. Van Sickle, p. 136.
A. History of development.	Tower, p. 29. Van Sickle, p. 118.
B. Types.	
1. In line.	
2. Vee.	
3. Double Vee (fan).	
4. X type.	
5. Opposed.	
6. Single row radial.	

7. Double row radial.
8. Rotary (obsolete).

C. Four stroke cycle. — Tower, pp.30-31.
   1. Intake.
   2. Compression.
   3. Power.
   4. Exhaust.

D. Basic engine parts. (nomenclature and function) — *Above and Beyond*, Vol. 11
   1. Cylinders.
   2. Valves.
   3. Camshaft.
   4. Push rods.
   5. Rocker arm assembly.
   6. Pistons.
   7. Piston rings.
   8. Wrist pin.
   9. Connecting rod.
   10. Master rods (radial engines).
   11. Bearings (rod inserts).
   12. Crankshaft.
   13. Crankcase.
   14. Accessories.
       a. Carburetor
       b. Fuel injection.
       c. Pumps
          1. Oil.
          2. Fuel.
          3. Vacuum.
       d. Magnetos.
       e. Generator.
       f. Starter.
   15. Systems.
       a. Induction.
       b. Ignition.
       c. Exhaust.
       d. Dual.
       e. Lubrication.
       f. Cooling.

E. Performance.
   1. Regulating power. — Van Sickle, pp. 142-143.
   2. Power indicators.
      a. Tachometer.
      b. Manifold pressure.
   3. Measuring power. — Van Deventer, pp. 180-181.
      a. Torque.
      b. Prony brake.

F. Fuels.
  1. Types.
  2. Fueling precautions.
    a. Static line.
    b. Fuel vapors.
    c. Condensation.

Briggs & Stratton engine for classroom demonstration of the fundamentals of reciprocating engines.

G. Fundamental engine requirements.
  1. Low weight over horsepower.
  2. Reliability.
  3. Durability.
  4. Compactness.
  5. Freedom from vibration.
  6. Low fuel/oil consumption.

Van Deventer, p. 176.

H. Superchargers.
  1. Performance without.
  2. Performance with.
  3. Construction.
    a. Impeller.
    b. Diffuser.
    c. Manifold.
  4. Types.
    a. Two-speed single stage.
    b. Two-stage turbo exhaust.

Van Sickle, p. 144
Van Deventer, p. 183.

I. Engine instruments.
  1. Purpose.
  2. Tachometer.
  3. Pressure gauge.
  4. Oil temperature.
  5. Cylinder head temperature.
  6. Manifold pressure.
  7. Fuel gauge.

Tower, p. 33.
Van Deventer, pp. 191-193.

J. Engine controls.
  1. Throttle.
  2. Mixture control.
  3. Carburetor heat.
  4. Propeller pitch.
  5. Ignition (magneto switch)
  6. Master switch.

K. Propellers.
  1. Theory.
    a. Momentum.
    b. Blade element.
  2. Tip speed.
  3. Propeller components.
    a. Hub.
    b. Blade.
    c. Tip.

Van Deventer, p. 193.
Van Sickle, p. 120.

Tower p. 35, Ch.V.

        - d. Leading edge.
        - e. Trailing edge.
        - f. Pitch (working pitch).
    - 4. Types of propellers.
        - a. Fixed pitch.

          Above and Beyond, Vol.10
            - 1. Wood.
            - 2. Metal.
        - b. Adjustable pitch.
        - c. Two-position propeller.
        - d. Variable pitch.
            - 1. Electric.
            - 2. Hydraulic.
            - 3. Mechanical.
        - e. Constant speed.
        - f. Feathering.
        - g. Reversible pitch.

IX. Reaction Engines

Consult: A Source Book for the Physical Sciences, pp. 359-365.

- A. Newton's Laws of Motion, No. 1, No. 2, and No. 3.
- B. History of development. Hero's Aeolipile

  See Figure 20.
- C. Rocket motors.

  Van Deventer, p. 201.
- D. Thrust horsepower.

  Van Deventer, pp. 202-203.
- E. Gas turbine function.

  Van Deventer, p. 203.
- F. Components of jet engine.

  Tower, p. 43.
  Van Deventer, pp. 204-217.

  Use Revell model of a turboprop engine, 501 D-13.
    - 1. Intake.
    - 2. Compressor.
    - 3. Combustor.
    - 4. Turbine.
    - 5. Exhaust.
- G. Classification of turbo jet engine.
    - 1. Axial-flow compressor.
    - 2. Centrifugal flow.
    - 3. Dual axial-flow.
- H. Variable inlet.
- I. Afterburner.

  Above and Beyond, Vol. 1
- J. Variable-area orifice.
- K. Thrust reverser.
- L. Exhaust silencer.

M. Turbofan.	Refer to exhibit 2.
N. Turboprop.	
O. Other reaction-type engines.	"Engineered for Power," Solar Aircraft Co.
1. Pulse jet.	
2. Ram jet.	
3. Rocket.	
a. Solid fuel.	
b. Liquid fuel.	
X. Helicopters	
A. Types.	Van Deventer, pp. 385-396.
1. Single main rotor and tail rotor.	Van Sickle, p. 656-684. Tower, p. 67.
2. Twin coaxial rotors.	
3. Twin outboard rotors.	
4. Twin intermeshing rotors.	
5. Twin tandem rotors.	
6. Single rotor with outboard propeller.	
B. Aerodynamics.	
1. Airfoil design.	
2. Forces on rotor blades.	
3. Coning angle.	
4. Rotor disc.	
5. Flight controls.	Van Sickle,p. 672.
C. Hovering flight.	
D. Horizontal flight.	
1. Dissymmetry of lift.	Van Sickle, p. 665.
2. Flapping hinge.	
3. Drag hinge.	
4. Articulated rotor.	
5. Tilting the rotor disc.	
6. Torque correction.	
E. Autorotation.	

BASIC LAWS OF MOTION

Basic laws of motion lead to an understanding of the forces acting upon an airplane in flight:

1. Gravitational Force: The attraction between the earth and all bodies on or near it. This force between two bodies is directly proportional to the product of their masses and is inversely proportional to the square of the distance between them:

$$F \propto \frac{M_1M_2}{r^2}$$

2. Inertia: Objects at rest tend to stay at rest and objects in motion tend to continue in motion along the same straight line and without changing speed, unless acted upon by an outside force.

3. Linear Acceleration: The first law of motion implies that force is necessary to accomplish the following:

   A. To set an object in motion.

   B. To change the rate of an object already in motion.

   C. To change the direction of a moving object; an object's acceleration is directly proportional to the force producing the acceleration. Also, it is inversely proportional to the mass of the object being accelerated.

$$A \propto \frac{F}{M}$$

4. Centripetal and Centrifugal Force: Centripetal Force causes a body, already in motion, to move in a curved or circular path.

   Centrifugal Force is the apparent force that is equal to and in the opposite direction from the Centripetal Force

15/16

5. Momentum: Momentum is measured by the product of its mass and velocity.

6. Conservation of Momentum: Whenever one body attains momentum, some other body acquires an equal and opposite momentum.

7. Relative Motion: Most motion studied in aerodynamics is relative motion. The pilot must be concerned with the wind direction relative to the ground.

8. Work: This is the result of the product of a force times the distance through which the force acts. Measuring force in pounds, and distance in feet, the work accomplished is expressed in foot-pounds.

$$W = F \times S$$

9. Power: This is the unit as used in aeronautics for the measurement of rate of work or power (horsepower). When a machine accomplishes work at the rate of 550 foot-pounds per second or 33,000 foot-pounds per minute, the result is one horsepower.

10. Energy: The ability of a body to do work.

    Potential: If work has been done in raising an object to height against the force of gravity, the object is said to possess kinetic energy equal to the work done in bringing it up to its velocity.

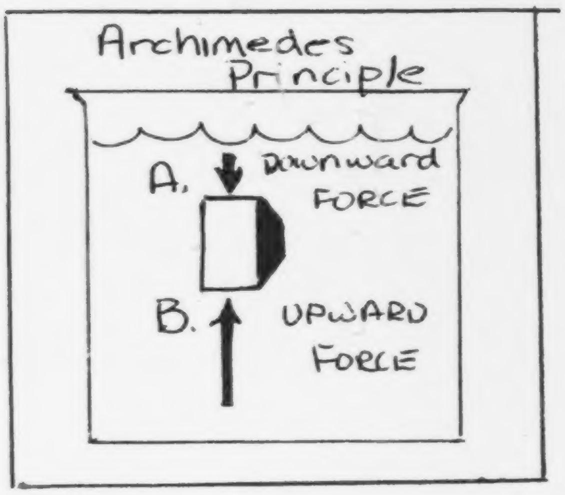

Archimedes Principle
A. Downward FORCE
B. UPWARD FORCE

Fig.2. ARCHIMEDES PRINCIPLE

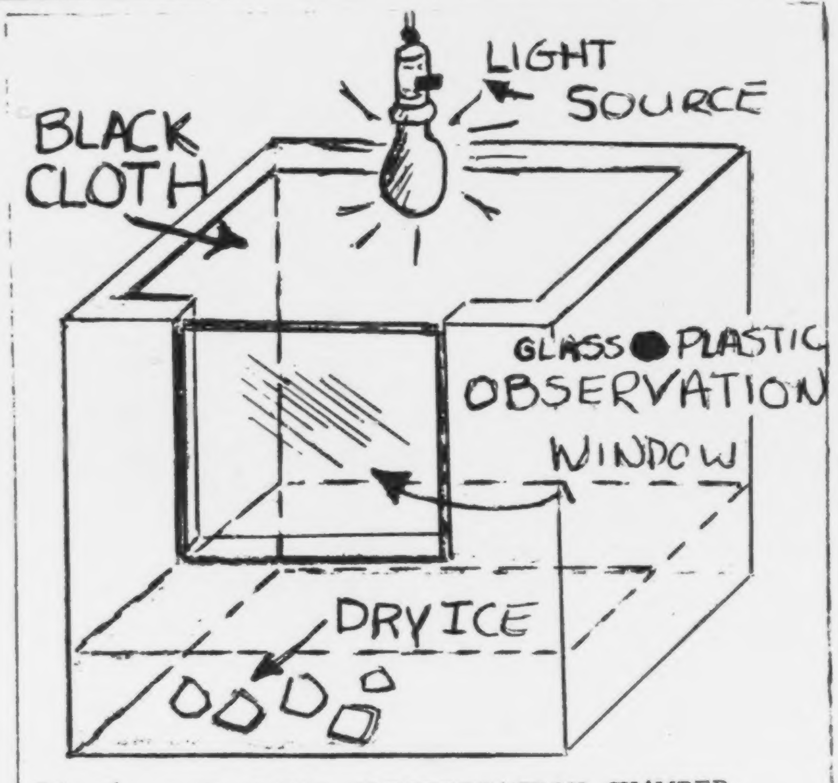

LIGHT SOURCE
BLACK CLOTH
GLASS ● PLASTIC OBSERVATION WINDOW
DRY ICE

Fig.1. ICE CHEST PRECIPITATION CHAMBER

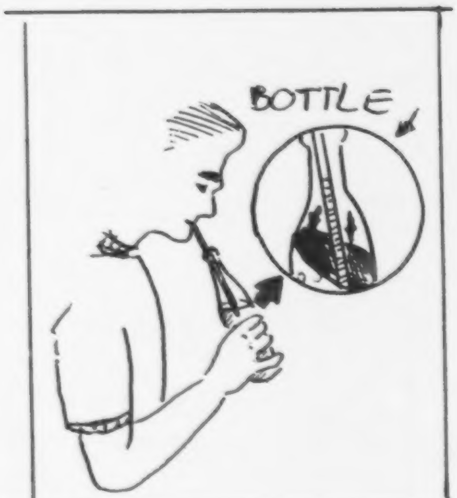


Fig.3. ATMOSPHERIC PRESSURE FORCES FLUID UP INTO STRAW

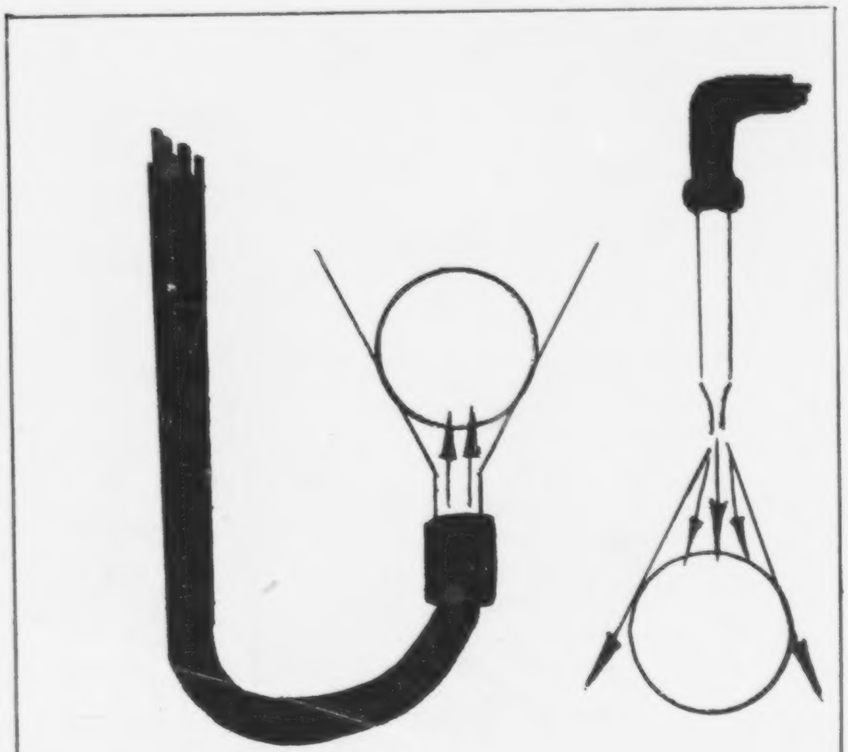


Fig.4. BERNOULLI PRINCIPLE PING PONG BALL AND AIR STREAM

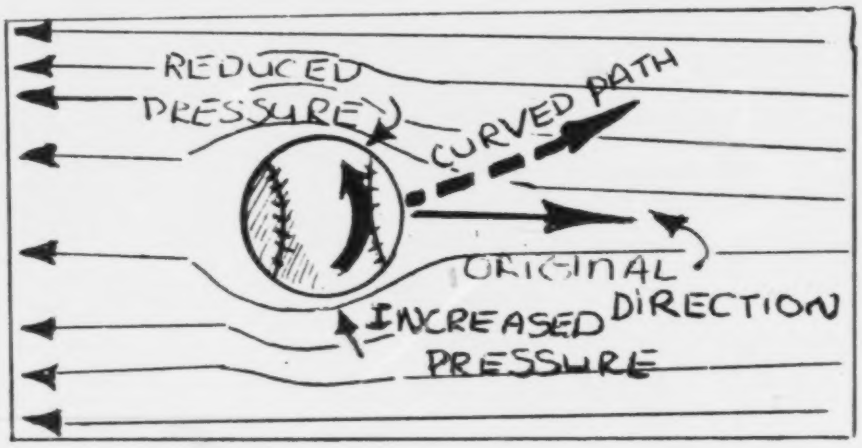

REDUCED
PRESSURE
CURVED PATH
ORIGINAL DIRECTION
INCREASED
PRESSURE

Fig.5. BERNOULLI PRINCIPLE
EFFECT UPON BASEBALL

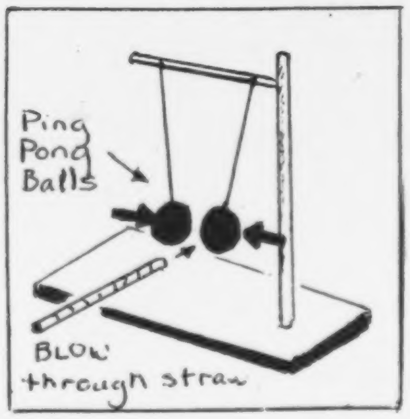

Ping
Pong
Balls
BLOW
through straw

Fig.6. BERNOULLI PRINCIPLE

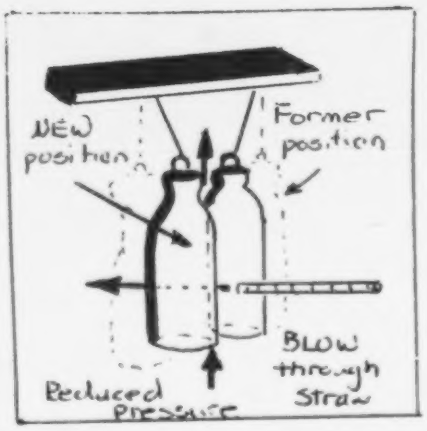

NEW
position
Former
position
Reduced
Pressure
BLOW
through
Straw

Fig.7. BERNOULLI PRINCIPLE

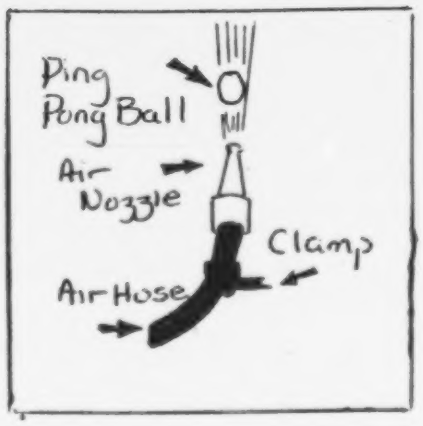

Ping
Pong Ball
Air
Nozzle
Clamp
Air Hose

Fig.8. BERNOULLI PRINCIPLE

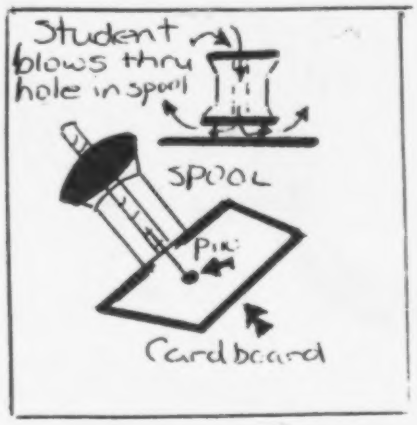

Student
blows thru
hole in spool
SPOOL
Pin
Cardboard

Fig.9. BERNOULLI PRINCIPLE

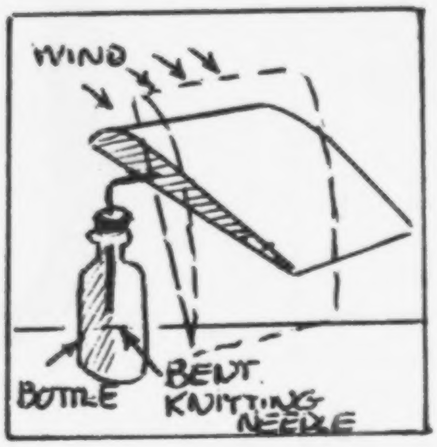

WIND
BOTTLE
BENT
KNITTING
NEEDLE

Fig.10. TOP ACTION

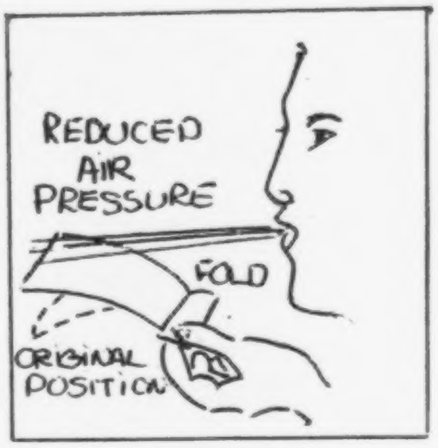

REDUCED
AIR
PRESSURE
FOLD
ORIGINAL
POSITION

Fig. 11. TOP ACTION

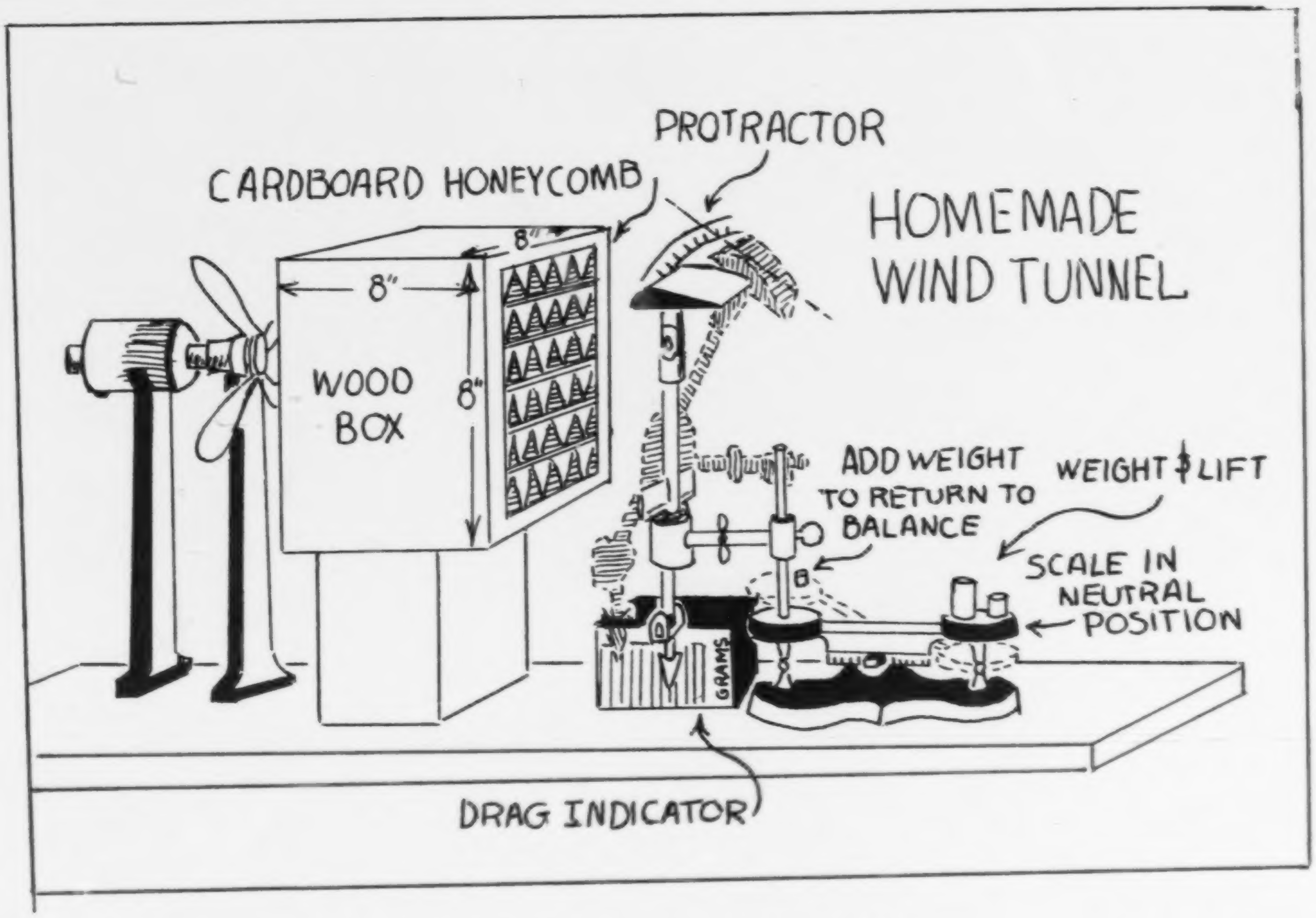

PROTRACTOR
CARDBOARD HONEYCOMB
HOMEMADE WIND TUNNEL
8"
8"
8"
WOOD BOX
ADD WEIGHT TO RETURN TO BALANCE
WEIGHT & LIFT
SCALE IN NEUTRAL POSITION
GRAMS
DRAG INDICATOR

Fig.12. WIND TUNNEL TO MEASURE DRAG

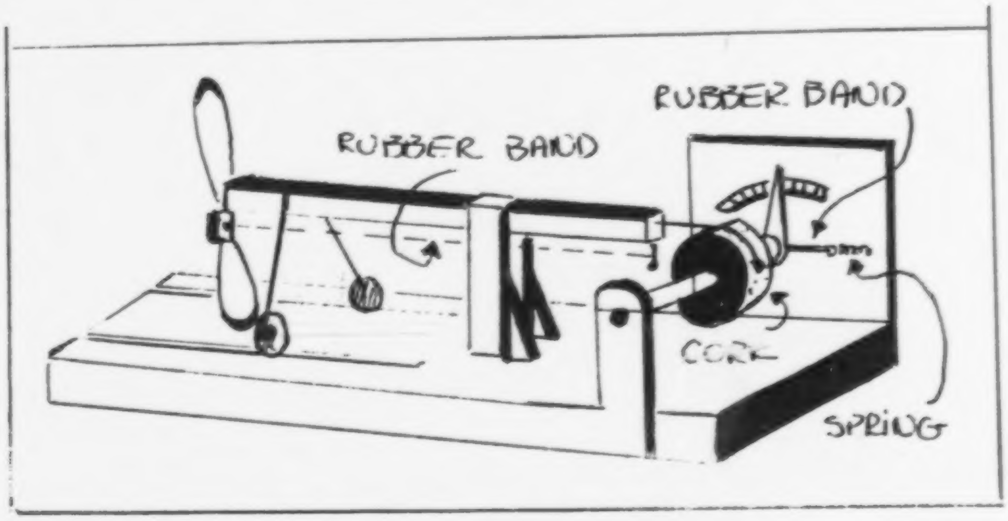
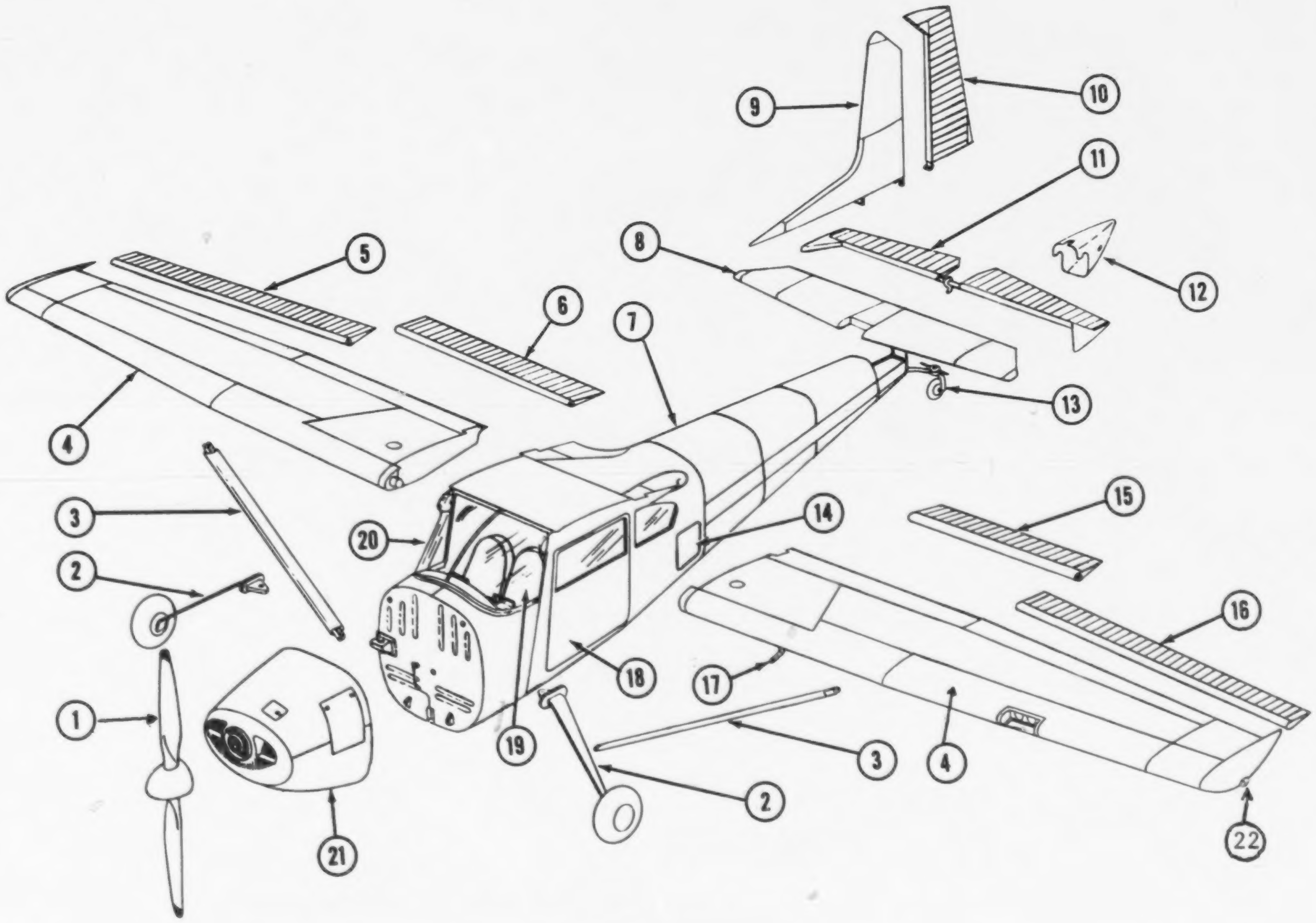

RUBBER BAND
RUBBER BAND
CORK
SPRING

Fig.13. DEVICE TO MEASURE THRUST

Fig. 14 PARTS OF AN AIRPLANE



(Courtesy Cessna Aircraft Company)

1. Propeller
2. Landing Gear
3. Wing Strut
4. Wing
5. Right Wing Aileron
6. Right Wing Flap
7. Fuselage
8. Horizontal Stabilizer
9. Fin and Dorsal
10. Rudder
11. Elevator
12. Stinger
13. Tailwheel
14. Baggage Door
15. Left Wing Flap
16. Left Wing Aileron
17. Pitot
18. Door
19. Front Seat
20. Windshield
21. Engine Cowl
22. Navigation light (red)

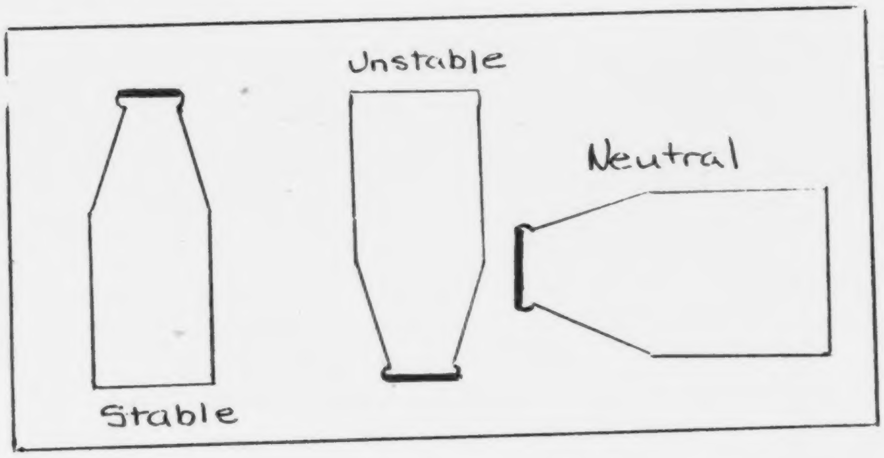

Unstable
Neutral
Stable

Fig. 15 TYPES OF STABILITY

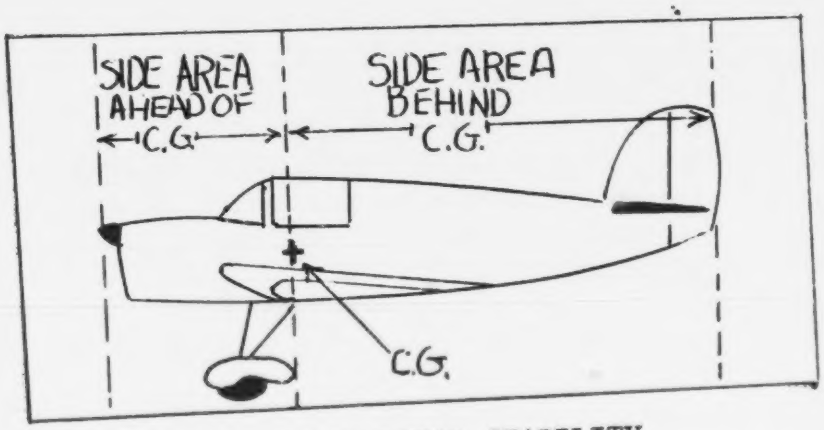
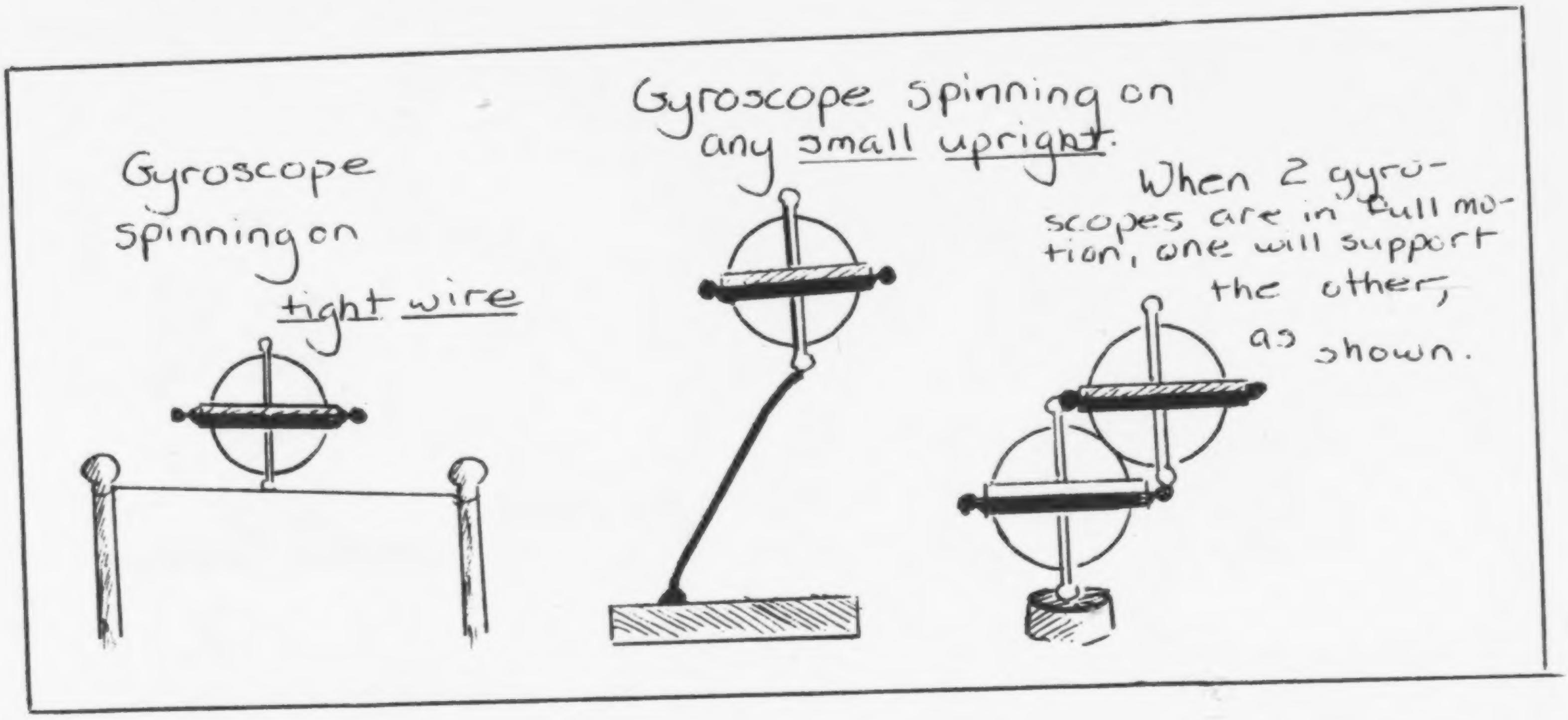

SIDE AREA AHEAD OF C.G
SIDE AREA BEHIND C.G.
C.G.

Fig. 16. DIRECTIONAL STABILITY


Gyroscope spinning on tight wire
Gyroscope spinning on any small upright.

When 2 gyroscopes are in full motion, one will support the other, as shown.

Fig. 17 GYROSCOPE

GYROSCOPIC MOTION

Precession: Most of the phenomena of precession may be shown with a bicycle wheel equipped with handles on the ends of its axle. The wheel is given a spin by hand and one handle is slipped into a loop of string for support. When the other handle is released, the wheel precesses about a vertical axis while its own horizontal axis of spin slowly descends toward the vertical. If the precession is accelerated by pressure on the unsupported end of the axle in the direction of precession, the center of gravity rises. As the spin of the wheel diminishes, the wheel precesses more rapidly, or the precession may be made more rapid by adding a weight to the unsupported end of the axle. If the other end of the axle is supported in the loop of string, the sense of spin being unchanged, the direction of precession will reverse. From these simple phenomena, several of the important rules of gyroscopic motion may be worked out, such as the relation between directions of spin, torque, and precession and the relation between the magnitudes of spin, torque, and precession.

Since angular momentum is a vector quantity that may be conveniently represented by a vector parallel to the axis of spin, the combination of two angular momenta may be treated by the parallelogram law. Thus, whenever a gyroscope is acted upon by a torque tending to produce rotation about an axis perpendicular to the axis of spin, or of precession, the gyroscope will precess about a third axis perpendicular to the other two.

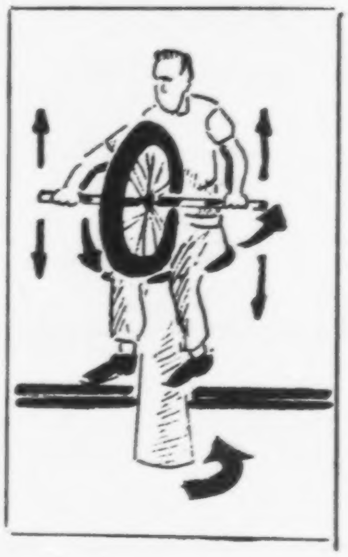


Fig. 18. GYROSCOPIC PRECESSION

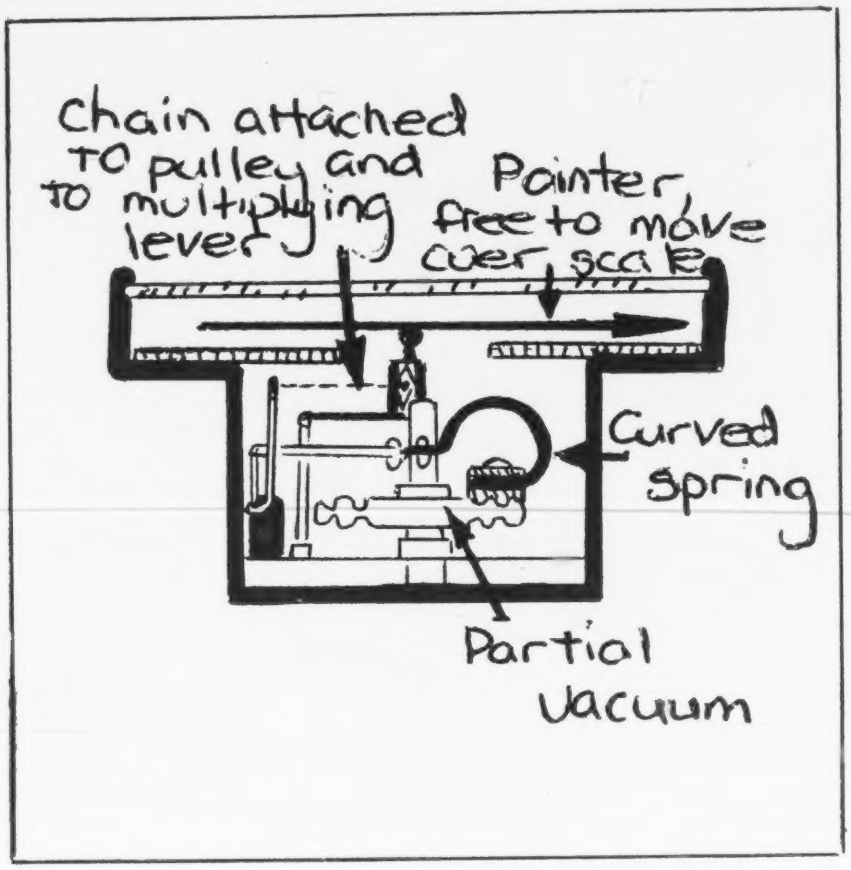

Chain attached
to pulley and
to multiplying
lever
Pointer,
free to move
over scale
Curved
spring
Partial
vacuum

Fig.19. CROSS SECTION OF AN ANEROID BAROMETER

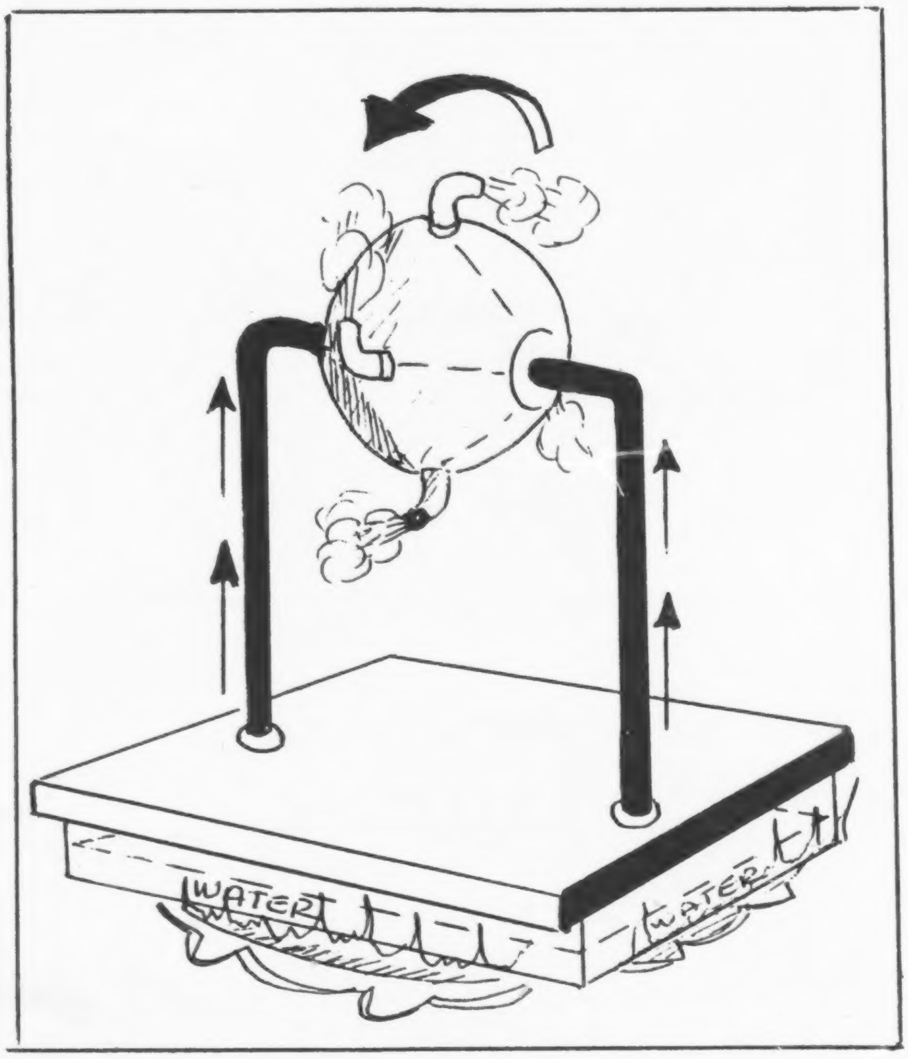
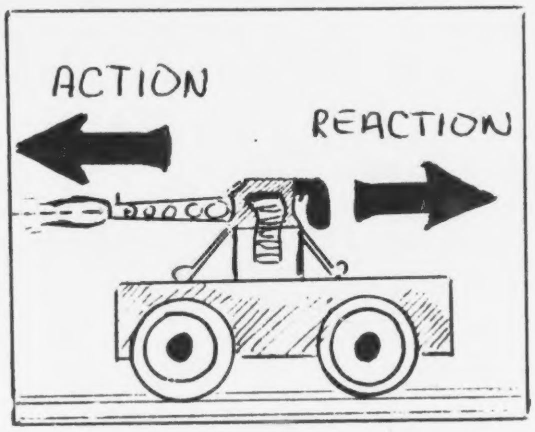
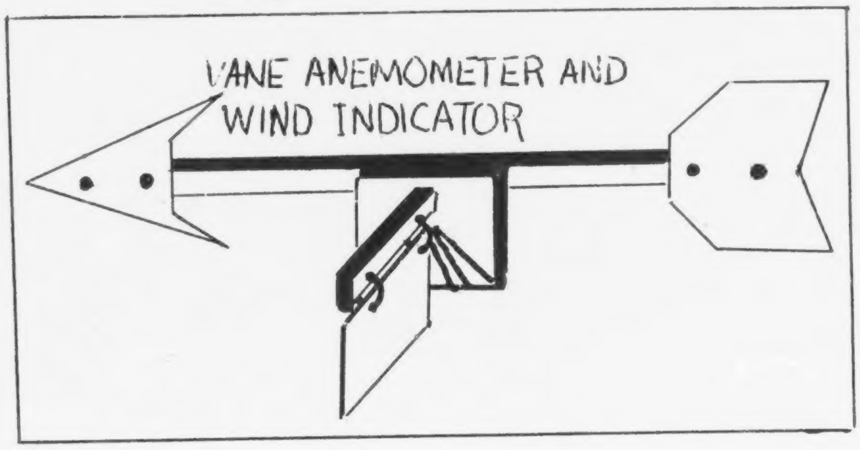
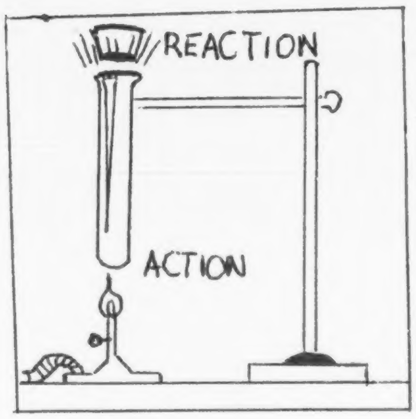
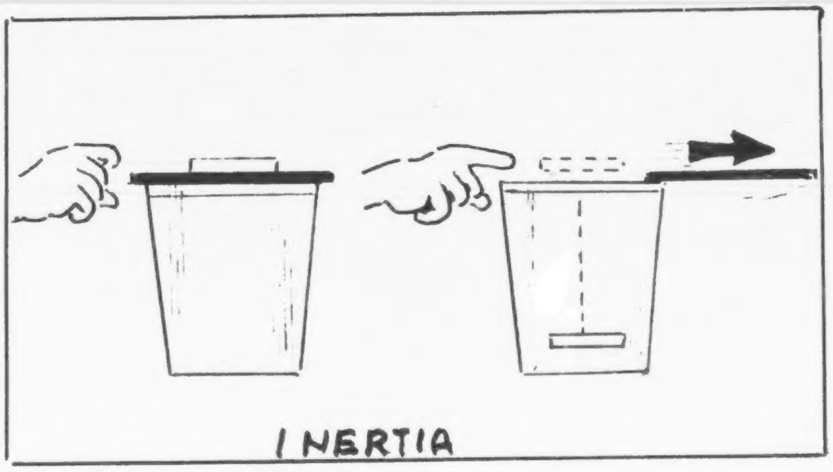

WATER
WATER

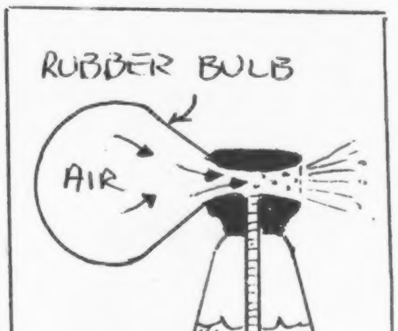
Fig.20. HERO'S AEOLIPILE NEWTON'S 3RD LAW

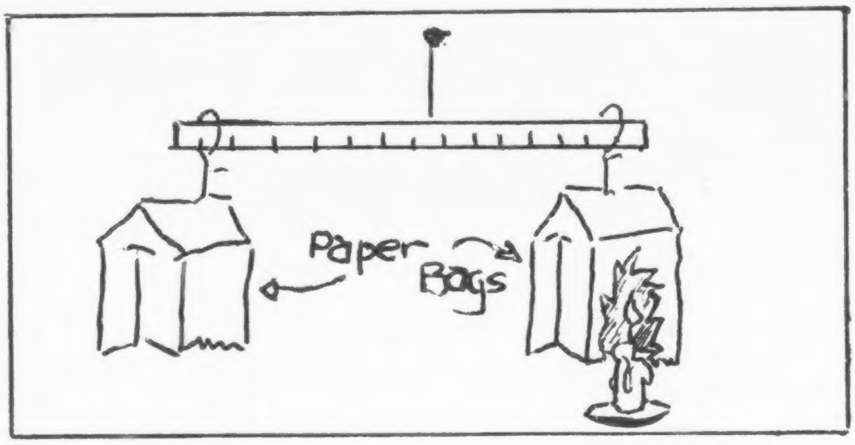

ACTION
REACTION


VANE ANEMOMETER AND
WIND INDICATOR

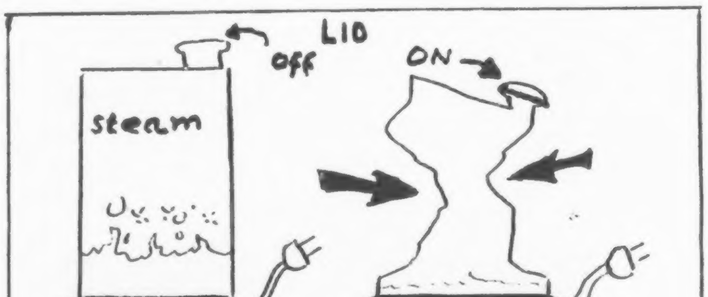

REACTION
ACTION

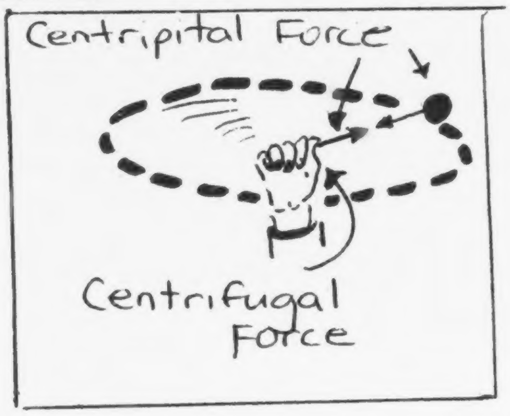


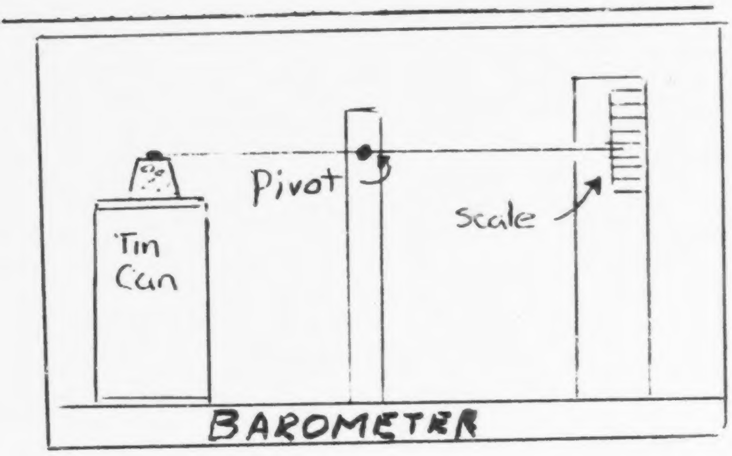

RUBBER BULB
AIR



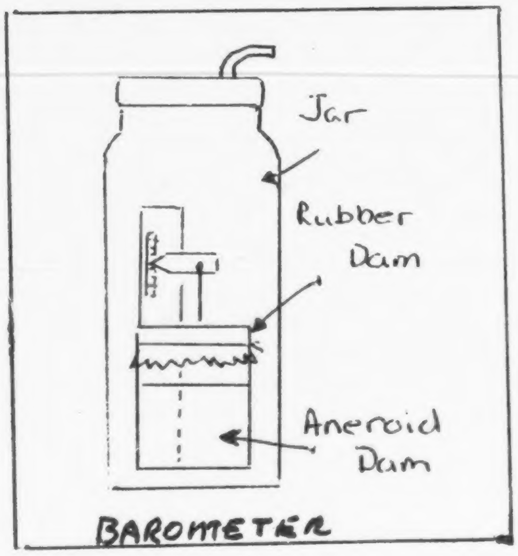
ATMOSPHERIC PRESSURE


LID
off
ON
steam

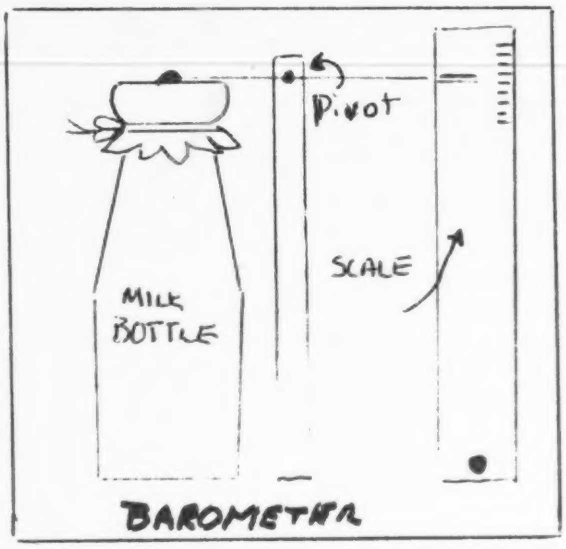

Centripital Force
Centrifugal Force


Tin Can
Pivot
Scale

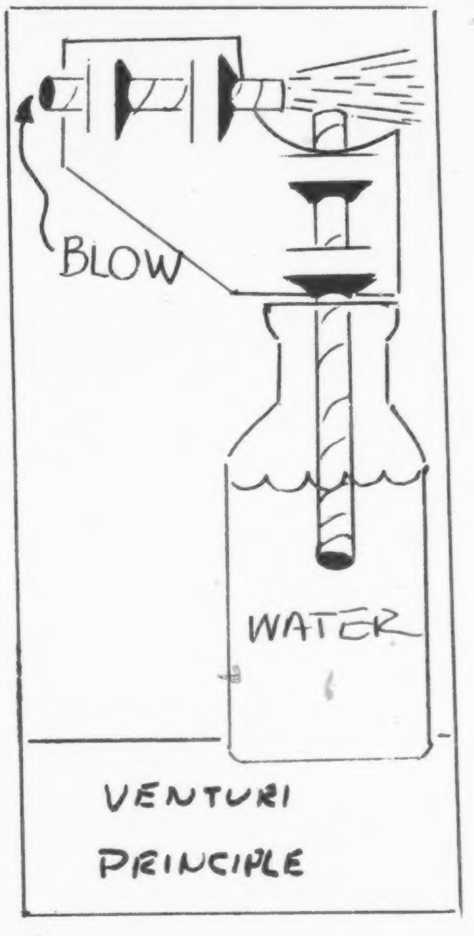
BAROMETER


Jar
Rubber Dam
Aneroid Dam

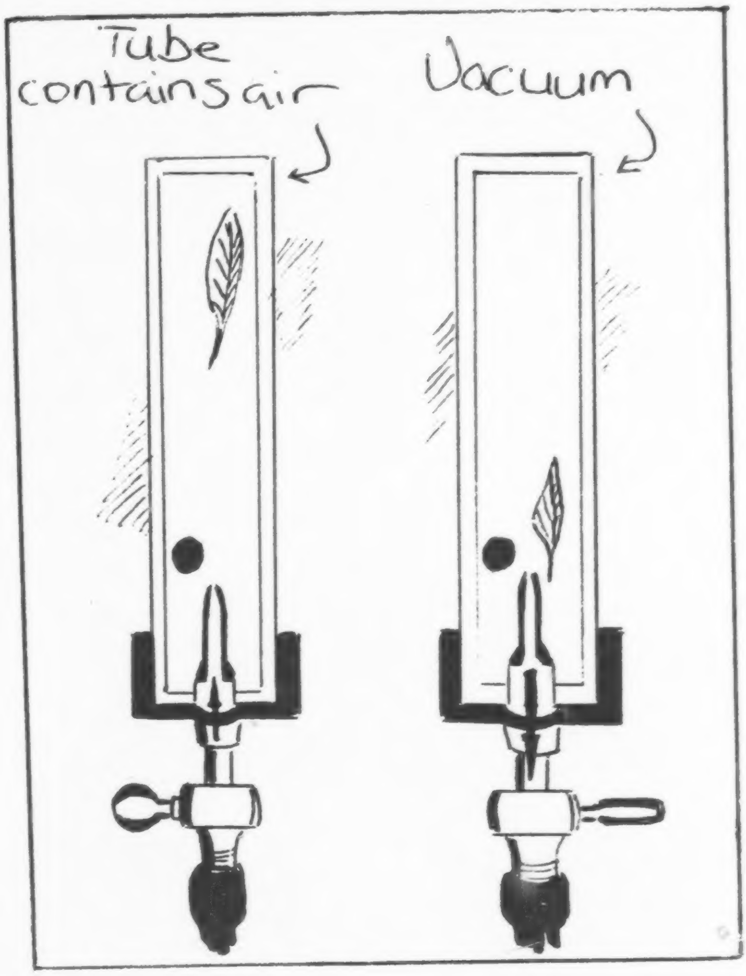
BAROMETER


Pivot
MILK BOTTLE
SCALE

BAROMETER



VENTURI PRINCIPLE


Tube contains air
Vacuum

RESOURCES

Materials:

Flight or Ground Simulator (Link, GAT 1, or Frasca Trainer)
Engine charts, etc.
Engines and parts
Propeller
Assorted flight and engine instruments
Model aircraft with movable controls and surfaces

Textbooks:

Above and Beyond: The Encyclopedia of Aviation and Space Sciences. Chicago: New Horizons Publishers, Inc., 1968.
Joseph, Alexander, Paul F. Branawein, Evelyn Morholt, Harvey Pollack and Joseph F. Castka, A Sourcebook for the Physical Sciences. New York: Harcourt, Brace & World, Inc., 1961.
Tower, Merrill, Basic Aeronautics. Fallbrook, California: Aero Publishers, 1955.
Van Deventer, C. N., An Introduction to General Aeronautics. American Technical Society,1965.
Van Sickle, Neil D., Modern Airmanship, 3rd Ed., Princeton, N.J.: Van Nostrand, 1966, 769 pp.

Reference Books and Information:

Aviation Education Research Group, Science of Pre-flight Aeronautics for High Schools. New York: Macmillan Co., 1942.
Bernardo, James V., Aviation and Space in the Modern World. New York: E. P. Sutton & Co., Inc., 1968.
Burns, Elmer E., Frank L. Verwiebe and Herbert C. Hazel, Physics A Basic Science. New York: Van Nostrand Co., Inc., 1948.
Bush, Robert E., Aeronautics, The First Step to Space. Washington, D.C.: NASA Space-Mobile Programs, Education Office, Goddard Space Flight Center.
Civil Air Patrol National Educational Advisory Committee, Aviation Study Manual. Washington, D. C.: Civil Air Patrol, 1949.
Dull, Charles E., N. Clark Metcalfe and John E. Williams, Modern Physics. New York: Henry Holt & Co., 1960.
*Federal Aviation Administration, FAA Advisory Circulars:

00-2	"Advisory Circular Checklist. (Latest Revision)
20-37A	"Aircraft Metal Propeller Blade Failure," (4-4-69)
20-43	"Aircraft Fuel Contamination," (9-3-65).
60-1	"Know Your Aircraft," (6-12-63)
61-16	"Flight Instructor's Handbook, (1-19-65). ($1.25, GPO).
61-23	"Private Pilots' Handbook of Aeronautical Knowledge (5-27-66). ($2.75 GPO).

*See page 244 for information on how to obtain copies.

NOTICE: Prices indicated herein are subject to change.

Gentle, Ernest and Charles E. Chapel, *Aviation and Space Dictionary*. Los Angeles: Aero Publishers, Inc., 1961.

Hicks, Betty, *The Ground School Workbook*. Ames, Iowa: Iowa State University Press, 1965.

Misenhimer, Ted G., *Aeroscience*. Culver City, California: Aero Products Research, Inc., 1969.

Morgan, Howard E., *Turbojet Fundamentals*. Santa Monica, California: Duglas Aircraft Co., 1965.

National Aeronautics and Space Administration, *Aeronautics*. Washington, D.C.: U.S.Government Printing Office, 1967.

National Aeronautics and Space Administration, *The Shapes of Tommorrow*. Washington, D.C.: U.S.Government Printing Office, 1967.

Pope, Frances and Arthur S. Otis, *Elements of Aeronautics*. Yonkers-on-Hudson, New York: World Book Co., 1941.

Pratt & Whitney, *JT30, the Turbofan Engine & You*. Division of United Aircraft Corporation

Sanderson Films, Inc., *Aviation Fundamentals*. Wichita, Kansas: Sanderson Films, Inc., 1967.

Sanderson Films, Inc., *Pre-flight Facts*. Wichita, Kansas: Sanderson Films,Inc., 1966.

Simonson, LeRoy, *Private Pilot Examination Guide*, 3rd Ed. 11516 Cherry Avenue, Inglewood, California, 1964.

Solar Aircraft Company, *Engineered for Power*.

Weber, Walter B., *Aeronautical Instrument Projects*. Bloomington, Ill.: McKnight & McKnight, 1945.

Films:

*Beech Aircraft motion picture "Discover Flying", 1969, Color, 13 min.

*Federal Aviation Administration:
  "A Plane is Born," (FA-602). 1968, Color, 27 min.
  "How An Airplane Flies," (FA-703). 18 min.

*General Motors Corporation:
  "ABC of Internal Combustion." Color, 13 min.
  "ABC of Jet Propulsion." 1954, Color, 17 min.
*McGraw-Hill, "An Introduction to Jet Engines," (Code 652100). B/W, 14 min.
*Piper Aircraft, "Wings In Production," 27 min.
*Shell Oil Co., "History of the Helicopter," 20 min.
*Sikorsky Aircraft Co.
  "Detect and Destroy," 15 min.
  "Three If By Air," 14 min.
  "Vertical Assault," 16 min.
*See pages 233 and 234 for addresses.

**Other Aids*:

Aero Products Research Inc., Aeronautics course materials and instructors manual.

A. V. Company, materials for private pilot course.

Civil Air Patrol, *Demonstration Aids for Aviation Education*. Reprinted by the Federal Aviation Administration, GA-20, Wash. D.C. 20590

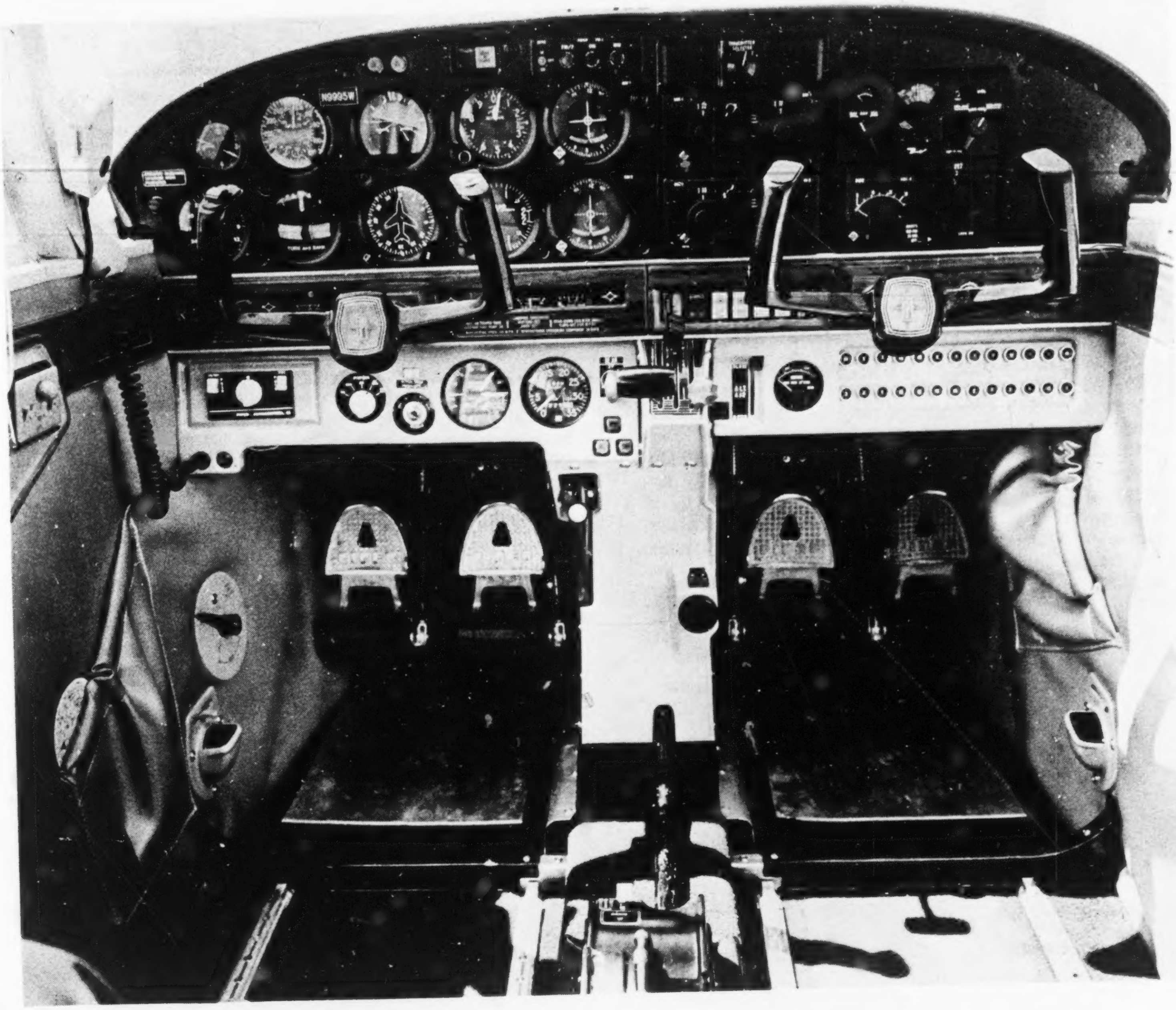
Jeppesen & Co., *"Airplane Operation and Performance."*

Piper Aircraft, various wall charts (2' x 3'). Instrument panel, aircraft production, parts of an airplane.

Sanderson Films,Inc., *"Pre-flight Facts"* and other course materials.

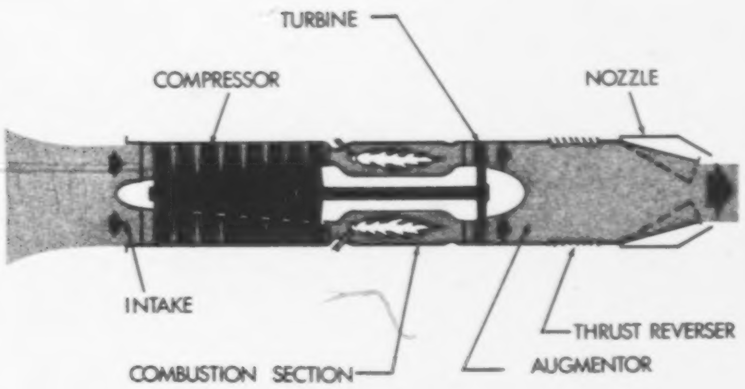
*See pages 245 and 246 for addresses.

EXHIBIT NO. 1


N9995W
TURN and BANK

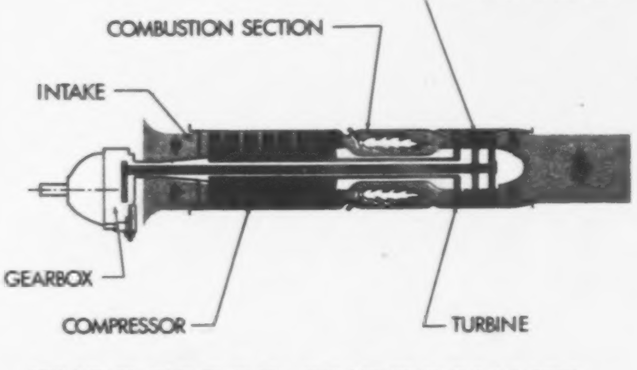
INSTRUMENT PANEL FROM PIPER AIRCRAFT

Here's how a jet engine operates ....



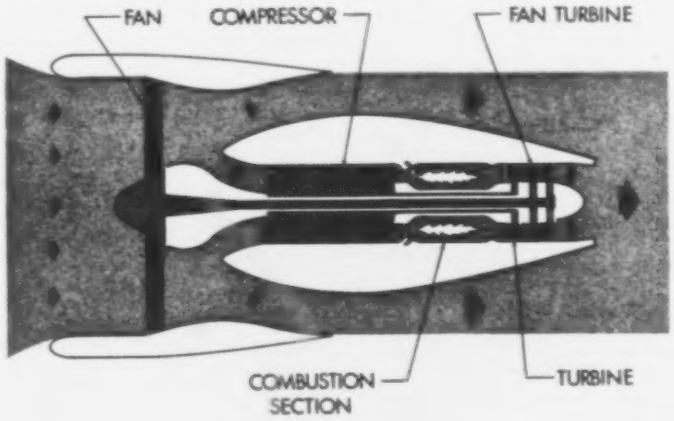
TURBOJET

The turbojet is the basic engine of the jet age. Air is drawn into the engine through the front intake. The compressor squeezes the air to many times normal atmospheric pressure and forces it into the combustion section. Here, fuel is sprayed into the compressed air, ignited and burned continuously like a blow-torch. The burning gases expand rapidly and blast rearward where they pass through a wheel-with-blades called a turbine. The turbine converts some of the force of rapidly expanding gases to rotational energy. This energy is transmitted by a shaft to the compressor which packs in more fresh air. After leaving the turbine, the hot gases blast their way out the rear of the engine, giving the aircraft its forward push . . . action, reaction!



TURBOPROP/TURBOSHAFT

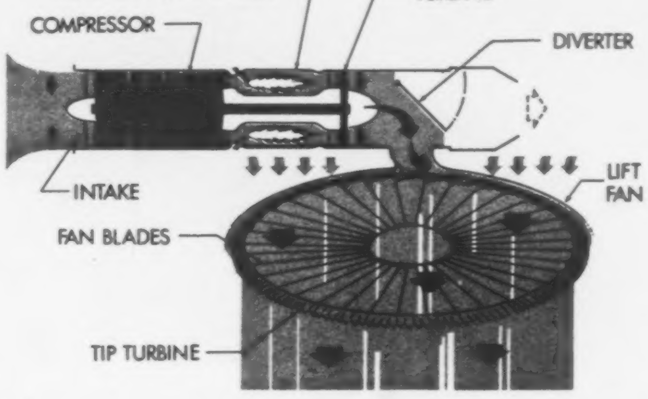
A turboprop engine uses thrust to turn a propeller. As in a turbojet, hot gases rushing through the engine rotate a turbine wheel which in turn drives the compressor. The gases then pass through another turbine called a power turbine at the end of the engine. This turbine is coupled to the shaft which drives the propeller through gear connections. A turboshaft is similar to a turboprop engine differing primarily in the job of the turbine shaft. Instead of driving a propeller, the turbine shaft is connected to a transmission system which drives helicopter rotor blades; or, in the non-aviation field such diverse equipment as power generators, locomotive booster engines and main propulsion units for hydrofoil ships.



TURBOFAN

A turbofan engine is basically a turbojet to which a fan has been added. Turbofans can be placed either at the front or the rear of the engine. In the case of a front-fan, the fan is driven by a second turbine (or set of turbines) located behind the primary turbine which drives the main compressor. The addition of the fan results in more air flowing around the engine than through it. This produces greater thrust and reduces specific fuel consumption at subsonic and certain supersonic speeds.

Sometimes, the fan and its driving turbine is placed at the rear of the engine. In this location the fan operates independently from the rest of the engine. The jet engine exhaust gases simply pass through the aft-fan turbine before exiting from the engine. Rotating at high speeds, the fan compresses additional air to supplement engine jet thrust.



TURBOTIP LIFT FAN

Turbotip lift fans supply power for both vertical take-off and landing and for straight and level flight. For vertical flight, turbojet exhaust is directed to tip turbines which drive the lift fans. The rotating fans create a large column of cool, low speed air for lift. After vertical take-off, transition to forward flight is accomplished by maneuvering control vanes or louvers mounted under each wing fan. As sufficient speed is attained for wing-supported flight, the diverter valves re-direct engine exhaust through tailpipes and nozzles for high-speed flight.

Courtesy General Electric Co.

31/32

INTRODUCTION

Weather has both blessed and plagued man since the beginning of time. Early man sought shelter from the elements in a cave. He discovered fire to warm himself. He learned to build on high ground or on stilts to keep his home dry. He discovered water repellent materials in which to clothe himself. More recently, he invented air conditioning to cool his abode. And yet man is still subject to the havoc wrought by seasonal storms and droughts. He repeatedly suffers from too much or too little precipitation, wind, and changes in temperature.

Understanding and forecasting weather is a challenge to man! The science of meteorology is the study of the most precious natural resource of his planet -- the atmosphere, which as a determiner of life is the most essential layer of the earth.

The study of weather and its effect is old, but, as a science, meteorology is comparatively new. It incorporates much of the earth sciences and more of the physical sciences. Meteorology follows certain basic laws; theories may be tested under controlled laboratory conditions; experimental measurements and data may be used to substantiate or invalidate theories; answers may be modified by new discoveries; and, finally, the findings may be applied to anticipate, to forecast -- and yes -- to control weather.

In the understanding and practice of meteorology lies man's hope to destroy hurricanes at sea, to induce precipitation to break a drought, to dissipate fog -- in short -- to become the master rather than be the victim of the forces of the world in which he lives.

TO THE TEACHER

The Meteorology unit in the Aeronautical Science Course is intended to help the student to accomplish the following goals:

1. To gain a useful knowledge of the atmosphere.
2. To learn to collect and classify data.
3. To draw generalizations from the total data.
4. To modify generalizations in the light of new information.
5. To apply the conclusions that have been reached.
6. To appreciate the benefits the atmosphere affords.
7. To respect the dangers inherent in weather.
8. To understand the behavior of weather.
9. To use to personal advantage the physical principles involved in meteorology.
10. To become aware of the career opportunities in meteorology in civilian and military life and in space exploration.

Demonstrations throughout the course outline are described in detail and may be found at the end of the course outline.

References throughout the course outline are to sources listed at the back of the unit on the page entitled "Resources."

A few concepts that teachers may want to impart to students early in the unit are as follows:

1. The three major elements responsible for the circulation of the earth's atmosphere are the heat of the sun, the rotation of the earth, and the friction between the earth's irregular surface and the air itself.

2. Weather is the condition of the atmosphere at a certain place at a given time. It involves various factors such as atmospheric pressure, moisture, temperature, wind, clouds and fog, and precipitation.

3. Climate is the average weather in a locality over a number of years.

4. Oceans are the great thermostats of the maritime climates, whereas the continental climates are controlled more directly by the sun.

Aviation Weather Teletype Service -- The unit on Meteorology can be handled most effectively if the students have a chance to actually use weather information. Teletype weather service can be procured through the local telephone company (AT&T) with the permission of the ESSA Weather Bureau.

TO THE TEACHER (Cont'd)

Rates for teletype service vary from one location to another, but they average about $100 per month for the teletype, $65 installation charge, and about $25 per month for paper. The service best suited to this course is Teletype Service A, operated by the Federal Aviation Administration with the actual weather information coming from ESSA.

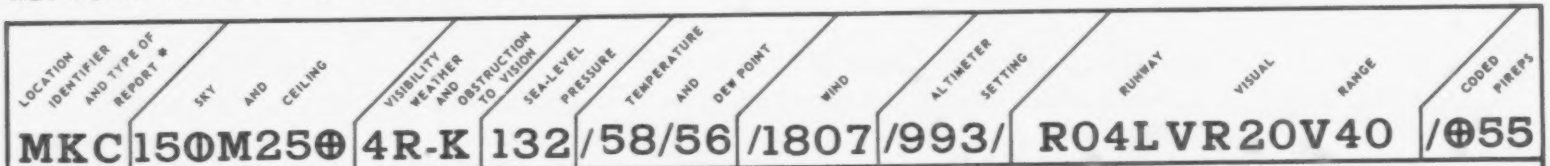
Traffic on Service A consists of:

12-hour terminal forecasts
Winds aloft forecasts
Aviation area forecasts
In-flight weather advisories (AIRMETS and SIGMETS)
Notices to Airmen (NOTAMS)

The teletype circuit runs 24 hours a day seven days a week. An automatic paper roller is available to roll up the reports when the machine is unattended. The machine can be shut off if desired. It is suggested that students work individually or in groups of two or three to plot weather maps and make forecasts. The machine is noisy so it should be installed in a small room or closet which is separate from the classroom.

To obtain aviation teletype weather service it is suggested that the teacher take the following steps: (1) obtain a cost estimate from your local telephone business office, (2) write the Weather Bureau (ESSA) in Washington, D.C., at the address listed at the end of this unit for permission, and (3) order the service from your local telephone business office after permission is granted by ESSA.

KEY TO AVIATION WEATHER REPORTS......



SKY AND CEILING

Sky cover symbols are in ascending order. Figures preceding symbols are heights in hundreds of feet above station.

Sky cover symbols are:

○ Clear: Less than 0.1 sky cover
⦶ Scattered: 0.1 to less than 0.6 sky cover.
⦷ Broken: 0.6 to 0.9 sky cover.
⊕ Overcast: More than 0.9 sky cover
in (When prefixed to the above symbols.)
tial obscuration: 0.1 to less than 1.0 sky hidden by ecipitation or obstruction to vision (bases at surface)
X Obscuration: 1.0 sky hidden by precipitation or obstruction to vision (bases at surface)

Letter preceding height of layer identifies ceiling layer and indicates how ceiling height was obtained. Thus:

A	Aircraft	R	Radiosonde Balloon or Radar.
B	Balloon (Pilot or ceiling).	W	Indefinite
D	Estimated height of cirriform clouds on basis of persistency.	U	Height of cirriform. ceiling layer unknown.
		/	Height of cirriform non-ceiling layer unknown.
E	Estimated heights of noncirriform clouds.	"V"	Immediately following numerical value indicates a varying ceiling.
M	Measured		

VISIBILITY

Reported in Statute Miles and Fractions. (V=Variable)

WEATHER AND OBSTRUCTION TO VISION SYMBOLS

A	Hail	F	Fog	RW	Rain Showers
AP	Small Hail	GF	Ground Fog	S	Snow
BD	Blowing Dust	H	Haze	SG	Snow Grains
BN	Blowing Sand	IC	Ice Crystals	SP	Snow Pellets
BS	Blowing Snow	IF	Ice Fog	SW	Snow Showers
D	Dust	K	Smoke	T	Thunderstorm
E	Sleet	L	Drizzle	ZL	Freezing Drizzle
EW	Sleet Showers	R	Rain	ZR	Freezing Rain

Precipitation intensities are indicated thus :
-- Very Light; — Light; (no sign) Moderate; + Heavy

WIND

Direction in tens of degrees from true north, speed in knots. 0000 indicates calm. G indicates gusty. Peak speed of gusts follows G or Q when squall is reported. The contraction WSHFT followed by local time group in remarks indicates wind-shift and its time of occurrence. (Kts. x 1.15 = statute mi/hr.)

EXAMPLES: 3627 360 Degrees, 27 Knots;
3627G40 360 Degrees, 27 Knots Peak speed in gusts 40 knots.

ALTIMETER SETTING

The first figure of the actual altimeter setting is always omitted from the report.

RUNWAY VISUAL RANGE (RVR)

RVR is reported from some stations. Extreme values for 10 minutes prior to observation are given in hundreds of feet. Runway identification precedes RVR report.

CODED PIREPS

Pilot reports of clouds not visible from ground are coded with MSL height data preceding and/or following sky cover symbol to indicate cloud bases and/or tops, respectively.

DECODED REPORT

Kansas City: Record observation, 1500 feet scattered clouds, measured ceiling 2500 feet overcast, visibility 4 miles, light rain, smoke, sea level pressure 1013.2 millibars, temperature 58°F, dewpoint 56°F, wind 180°, 7 knots, altimeter setting 29.93 inches. Runway 04 left, visual range 2000 ft. variable to 4000. Pilot reports top of overcast 5500 feet.

*TYPE OF REPORT

The omission of type-of-report data identifies a scheduled record observation for the hour specified in the sequence heading; the time of an out-of-sequence, special observation is given as "S" followed by a time group (24-hour clock GMT) e.g., "PIT S 0715 -XM..." A special indicates a significant change in one or more elements. Local reports are identified by "LCL" and a time group. Locals are transmitted on local teletypewriter circuits only.

U.S.DEPARTMENT OF COMMERCE • ENVIRONMENTAL SCIENCE SERVICES ADMINISTRATION • WEATHER BUREAU Washington, D.C. Revised April 1966

For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C., 20402 - Price 5 cents; $2.25 per 100 GPO : 1966 O—211-765

UNIT OUTLINE

	FAA Aviation Weather;
I. The Atmosphere and Weather	Sanderson Meteorology Records and Filmstrips.
A. Composition of the earth's atmosphere.	Misenhimer - Meteorology Unit.
B. Temperature.	
1. Temperature measurement.	Use Demonstration A.
2. Daily range of temperature.	
3. Temperatures aloft.	Use Demonstration F.
4. Surface temperature distribution.	
C. Atmospheric Pressure	
1. Barometers.	Use Demonstration C.
2. Station pressure and pressure variations.	
3. Sea level pressure.	Use Demonstration E.
4. Pressure systems.	
5. Altimeters	
D. Wind	
1. Basic theory of the general circulation.	Van Sickle, p. 408.
2. Large wind systems.	
3. Local winds.	
E. Moisture	
1. Changes of state.	Use Demonstration D.
2. Moisture content.	
3. Condensation and sublimation products.	Use Demonstration J.
F. Stability	
1. Lapse rates.	
2. Stability determinations.	
3. Some effects of stability and instability.	
G. Turbulence	
1. Convective currents.	Use Demonstration I.
2. Obstructions to the wind flow.	
3. Vertical wind shear and surface winds.	
4. Clear air turbulence.	
5. Categories of turbulence intensity.	See exhibits 1 and 2.
H. Clouds	
1. Cloud composition.	
2. Types of clouds.	Van Sickle, p. 42.
3. Cloud recognition.	Bryan, p.91.
4. Cloud formation and structure.	Use Demonstration G. Cloud Charts

I. Air Masses	
1. Source regions.	
2. Classification of air masses.	
3. Air mass modification.	
4. Air mass weather in winter.	
5. Air mass weather in summer.	
J. Fronts	
1. Frontal structure.	Van Sickle, p. 417.
2. The polar front.	
3. Factors influencing frontal weather.	Use Demonstration B and B Alternate.
4. Types of fronts.	
5. Frontolysis.	
6. Frontogenesis	
K. Thunderstorms	
1. Thunderstorm structure.	Van Sickle,p. 448.
2. Classification of thunderstorms.	
3. Do's and Don't's of thunderstorm flying.	
L. Icing	
1. Inflight structural icing - types and effects.	Van Sickle, p. 435.
2. Structural aircraft icing on the ground.	Use Demonstration H.
3. Powerplant icing.	
4. Cold weather operations.	
M. Common "IFR" producers	
1. Ceilings and visibility.	
2. Fog, haze, smoke, and precipitation.	
3. Obscured sky.	
II. Aviation Weather Services	Field trip to nearest U.S.Weather Bureau Office and/or FAA Flight Service Station or military base weather service.
A. The nation's aviation weather system.	
1. Weather bureau and the Federal Aviation Administration.	
2. Weather communications.	
3. Supporting functions.	
B. Weather observations	Van Sickle, p. 420.
1. Surface weather observations.	
2. Pilot weather reports.	
3. Upper air observations.	
C. Weather charts.	
1. Surface weather charts.	
2. Winds aloft charts.	
3. Prognostic significant weather charts.	

D. Aviation weather forecasts.	Van Sickle, p. 424.
1. Terminal forecasts.	
2. Area forecasts.	
E. Using and helping the weather service.	
1. Weather briefing services.	
2. The accuracy of aviation weather forecasts.	
III. Supplementary Material on Weather	
A. High altitude weather.	Van Sickle, p. 429.
1. The jet stream.	
2. Clear air turbulence.	
B. Arctic weather.	
C. Tropical weather.	
D. Soaring weather.	
IV. Weather Satellites	*Above and Beyond*, pp. 2459-2471; NASA Facts
A. Beginnings of atmospheric observations	
1. International Geophysical Year, 1957-1958	
2. Sounding Rockets	Bernardo, pp.295-297
3. Orbiting satellites	
a. Explorer VII	Bryan, p. 135
B. True weather satellites	
1. Types of satellites	Bernardo, pp. 292-295; Bryan, pp. 137-138.
2. Sensor equipment operation	
C. Information returned to earth	
1. Data used for forecasting	
2. Ground communications network	
3. Data processing satellite information	
4. World Weather Watch Plan	

EXPERIMENT I - Demonstrations

A. Radiant energy from the sun.

Place a thermometer in a bell jar so that it hangs free of the bottom and sides. Evacuate the jar as much as possible with a vacuum pump. Record the temperature indicated. Place the bell jar so that the mercury bulb of the thermometer is in the direct sunlight. Record the temperature change every five minutes until a constant temperature is recorded. Since most of the air has been removed from the bell jar, any increase in temperature must be due to radiation. Why is convection not a factor in this case?

B. Densities of fluids.

Place a cardboard partition in the middle of a battery jar or large beaker so that it fits snugly against the sides separating the container into two equal parts. Carefully pour hot water colored with red food coloring into one side of the container. Pour ice cold water colored green or blue into the other side. After the water in both sides has come to rest, quickly but carefully remove the cardboard partition by sliding it straight upward so as to create as little turbulence as possible. Observe the movement of cold water in relation to the movement of the hot water. Gases are fluids and, therefore, react somewhat like the water. Apply the observations to atmospheric movement.

Densities of fluids - Alternate method.

Prepare the battery jar and partition as described above. Make a concentrated salt water solution and color blue or green with food coloring. Place fresh water colored red in one side of the jar and pour the salt solution (sodium chloride) in the opposite side. Remove the partition. The boundary between the two solutions will slowly slant away from the vertical. The heavier salt water will flow under and displace the lighter fresh water. Apply this principle to lighter warm air masses as compared with heavier cold air masses.

C. Atmospheric pressure.

Place about 25 ml of water in an empty five gallon can. With the lid off, heat the can until the water boils and a good quantity of water vapor forms at the opening where steam is escaping. This will indicate that steam has displaced most of the air from the can. Quickly tighten the lid in place. Observe the action of atmospheric pressure on the container. If desired, measurements of the dimensions of the can may be made before the demonstration and the total force exerted on the can calculated, using a standard atmosphere as 14.7 lbs. per square inch.

D. Dew Point.

Place some chipped ice in a glass of water and carefully stir with the bulb tip of a thermometer. Watch carefully for the first dew formation on the exterior of the glass. Record the temperature. Quickly remove the remaining ice from the glass and watch for the dew to disappear from the glass. Record the temperature immediately. The average of the two temperatures is approximately equal to the dew point of the air in the room. Caution: Students should not be close enough to the glass for their breath to reach the sides of the glass. Since our breath is almost completely saturated with water at body temperature, dew will form before the dew point of room air is reached.

E. Vapor pressure related to atmospheric pressure.

Heat some water until it feels "lukewarm" and pour enough into a distilling flask to fill it about half full. Insert a thermometer into a one-hole rubber stopper and place the stopper in the mouth of the flask so that the thermometer bulb extends below the level of the water. Attach the hose of a vacuum pump to the side arm of the distilling flask so that the air may be evacuated from the flask. As the air pressure within the flask approaches the vapor pressure of the water, the water will begin to boil. Hold the flask in cupped hands so that the body warmth will increase the vapor pressure of the water. Note the temperature of the water as it boils. Relate this to what would happen to body fluids should a person fly high enough for the air pressure to equal the vapor pressure of body fluids. Relate this to pressurized cabins. Show that percentage of oxygen in high altitude air is essentially the same as that in low altitude air. Point out the importance of the oxygen partial pressure at high altitudes.

F. Rising air cools.

Rising air expands and must do the work of pushing back other particles in its environment. Energy is required to accomplish this work. The energy comes from the expanding gas and it is, therefore, cooled. To demonstrate this cooling, inflate an inner tube to a high pressure and allow the tube to remain in the room for twenty to thirty minutes until the temperature of the air within the tubes is equal to room temperature. Record room temperature by use of a thermometer. Place the mercury bulb of the thermometer in the stream of air which escapes when the tube valve is opened. Find the decrease in temperature due to the expanding air as it is released from the internal pressure within the inner tube.

G. Condensation and cloud formation.

Fill a shallow container such as a baking pan with hot water. Place it under a bell jar until the air within the bell jar is saturated with water vapor. Remove the pan and rapidly evacuate the air from the bell jar with a vacuum pump. Observe that the air in the jar becomes foggy when it is cooled by expansion to the saturation point.

H. Formation of snow crystals. (See Figure 1, Page 17)
Modify a styrofoam ice chest by cutting an observation window in the front of the ice chest and inserting a pane of glass or plastic, or tape a heavy acetate sheet in place over the opening. Cover the bottom of the chest with dry ice sufficient to lower the temperature in the chest below 0° C. Cover the side of the interior of the chest which is opposite to the observation window with black paper or cloth. Keep the chest covered with the styrofoam cover until ready to use. Place a brilliant light such as a "clamp-on" flood light with at least a 100 watt bulb above the chest so that it illuminates the interior. When ready for the demonstration, be sure that the observation window is free from condensation. Breathe directly into the cold chamber. When observed through the observation window, the droplets from the water vapor in your breath will appear as a cloud of water droplets and remain suspended in the cold air or fall very slowly. Breathe several more times if additional water droplets are desired. Pulverize a small quantity of dry ice and sprinkle it into the cloud formed from your breath. Observe that the cloud begins to sparkle due to newly formed ice crystals. The ice crystals will continue to grow for several minutes and then precipitate to the bottom of the chamber. The air in the chamber becomes clear and the demonstration may be repeated.

I. Thermals and convection currents.
Use a convection box with a candle under one chimney. Make a smoke generator by rolling a paper towel tightly, lighting the end and allowing it to burn for fifteen to twenty seconds. Blow out the fire by shaking the paper towel. Smoke should continue to flow from the smoldering end for some time. Place the smoldering end of the paper towel over the chimney directly above the burning candle. Note the direction of movement of smoke. Place the smoldering paper over the other chimney and observe the movement of smoke through the convection box. Relate to convection currents in the atmosphere.

J. Oceans influence the weather.
The high specific heat of water, the fact that more heat is required to warm water than to warm almost any other substance, enables oceans to influence the climate throughout the world. This can be illustrated graphically by using two flower pots, one filled with dry soil, and one filled with water soaked soil, and a pan of water. Place the three containers in a shady part of the classroom until their temperatures are approximately equal. Then place the three containers in the direct sunlight, preferably outside or by an open

window. Measure their temperature every few minutes by extending the bulbs of thermometers into the soil in both pots and by immersing a thermometer bulb in the pan of water. Plot the temperature measurements versus time of recording them on a graph. Pupils should be able to account for differences in the three temperature curves.

43/44

EXPERIMENT II - Student Laboratory Experiment

Establishing a weather station.

One of the purposes of science classes in secondary schools is that students learn to use the ways of the scientist to solve problems which have real meaning to them. Participating in the functions of a weather station can provide direct experience in the methods of science such as observing, recording, gathering and classifying data, interpreting data, finding relationships among data, predicting results, and modifying predictions and conclusions as new data becomes available. It is urged that the establishment of a weather station be given high priority when considering an Aeronautical Science class.

The basic instruments recommended for such a station include:

1. Two barometers, an aneroid and a mercurial.
2. A maximum-minimum thermometer.
3. A sling psychrometer.
4. A rain gauge.
5. An anemometer.
6. A wind vane.
7. A barograph (if possible).
8. A hygrothermograph (if possible).

A weather station can function throughout the school year, giving each student an opportunity to be responsible for recording data from each type of equipment by rotating areas of responsibility among the students.

Field trips to government weather stations should be included as part of the on-going activities of maintaining the weather station. Gathering a collection of various weather communications should be included in the field trip activities. Samples of the following should be obtained, if possible:

1. 12-hour terminal forecasts (FT1).
2. 24-hour terminal forecasts (FT2).
3. Area forecasts (FA).
4. Winds aloft forecasts (FD).
5. In-Flight advisories, AIRMET and SIGMET.

Setting up a weather forecast display in a prominent display case can serve to stimulate interest in the Aeronautical Science class. The entire student body will learn to stop and read the predictions.

It may be desirable to have students construct their own weather instruments for economic reasons as well as the educational value in the experience. Such home-made instruments often provide reasonably accurate data.

RESOURCES

Textbooks:

Above and Beyond: The Encyclopedia of Aviation and Space Sciences. Chicago: New Horizons Publishers, Inc., 1968.

Bernardo, James V., Aviation and Space in the Modern World. New York: E. P. Dutton & Company, Inc., 1968.

Bryan, Leslie, Fundamentals of Aviation and Space Technology. Urbana,Ill.: Institute of Aviation, University of Illinois, 1968.

Van Sickle, Niel D., Modern Airmanship, 3rd Ed. Princeton, New Jersey: Von Nostrand, 1966.

Reference Books and Information:

*Federal Aviation Administration, FAA Advisory Circulars:
- 00-2 "Advisory Circular Checklist" (Latest Revision)
- 00-6 Aviation Weather (5-20-65). ($4.00 GPO)
- 00-17 "Turbulence in Clear Air" (12-16-65).
- 00-24 "Thunderstorms" (6-12-68).
- 61-23 Private Pilots' Handbook of Aeronautical Knowledge (5-27-66) ($2.75 Government Printing Office, Wash.,D.C. 20402
- 90-12 "Severe Weather Avoidance (4-15-64).
- 90-14A "Altitude - Temperature Effect on Aircraft Performance" (1-26-68).
- 90-22A "Automatic Terminal Information Service (ATIS)" (10-9-68)
- 90-23A "Wake Turbulence" (12-21-65).
- 91-13 "Cold Weather Operation of Aircraft" (11-16-66).
- 91-14 "Altimeter Setting Sources" (2-15-67).

Misenhimer, Ted G., Aeroscience, Culver City: Aero Products Research, Inc. 1969.

Stewart, G., The Storm. Modern Library Edition, New York: Random House.

Van Deventer, C.N., An Introduction to General Aeronautics. American Technical Society, 1965.

Weather, Life Science Library, New York: Time Incorporated, 1966.

Weather Bureau (ESSA) - Pamphlets available from the U. S. Government Printing Office, Washington, D. C., 20402. 5¢ each. Make check or money order payable to "Superintendent of Documents" :
- Ice on Aircraft, Its cause and Effects. #C 30.65:2
- Jet Stream, Band of Very Fast Winds Found at High Altitudes. #C 30.65:3
- Turbulence, Its Causes and Effects. #C 30.65:4
- Mountain Wave, What it Means to the Pilot. #C 30.65:5
- Fronts, Their Significance to Flying. #C 30.65:13
- Aeronautical Climatology, Low Ceilings and Visibilities. #C 30.65:15
- Thunderstorms, 2 Parts. #C 30.65:7 and #C 30.65:8
- Aeronautical Climatology, Thunderstorms. #C 30.65:16

Weather, Forcasting The - Louis D. Rubin - New York: K.S.Giniger Co.,Inc. (To be published early 1970) - $5.95.

*See page 244 for information as to how to obtain copies.

METEOROLOGY

Films:

Bell Telephone Company, "Unchained Goddess."

*Federal Aviation Administration:
- "Density Altitude," (FA-603-A). 1966, Color, 29 min.
- "Wake Turbulence," (FA-610). 1966, Color, 14 min.
- "Meteorology - Ice Formation on Aircraft," (FAN-100), 1960, B/W, 21 min.
- "Fog and Low Ceiling Clouds - Advection Fog and Ground Fog," (FAN-101). 1962, Color, 23 min.
- "Fog and Low Ceiling Clouds - Upslope Fog and Frontal Fog." (FAN-102). 1962. Color, 9 min.
- "The Cold Front," (FAN-103). 1962, Color,15 min.
- "The Warm Front," (FAN-104). 1962, Color, 18 min.

*National Aeronautics and Space Administration:
- "Tiros, Experimental Weather Satellite," (Hq.a 25). 1960, Color, 14 min.
- "Tiros II, Experimental Weather Satellite," (HQ a-31). 1961 Color, 6 min.

*United States Navy:
- "Aerology," Parts I and II (MN-7409-A and 7409-B).
- "Hurricane Hunters," (MN-8339).

* Note: Refer to List of Film Producers and Distributors in back of Course of Study for addresses. (See pages 233, 234, and 235.)

Other Aids:

*Aero Products Research, Inc., Private Pilot filmstrips and records.

* A.V.Co., Private Pilot filmstrips and tapes.

ESSA, Weather Bureau, W-154, 8060 13th St., Gramax Bldg., Silver Spring, Md., 20910. Write for permission to install Aviation Weather Teletype Service.

ESSA - CLOUDS - A folder of 8 panels providing color photographs and descriptions of 26 cloud forms. Also description of how clouds give hints to denote weather. Photographs of thunder storms from weather radar scopes. For sale by Superintendent of Documents, Item: ESSA/P 1680002. 25¢

FAA, Teletype weather reports may be obtained from your nearest FAA Flight Service Station. (Consult your local telephone directory)

*Jeppesen & Company. Quick-reference plastic sheets, each with a condensed review of the following weather subjects:
- Basic Meteorology. $1.95 (PD 101)
- Fronts and Storms. $1.95 (PD 102)
- Weather Maps. $1.95 (PD 103)
- Teletype Weather Reports. $1.95 (PD 104)

*Sanderson Films, Meteorology for the Private Pilot, filmstrip, records and course manual.

Whittet & Shepperson Publishing Co., 3rd and Canal, Richmond, Va. 23204. Cloud Chart. This chart contains 35 color photographs to aid in the interpretation of cloud reports in the international figure code plus information on foretelling weather by clouds, how clouds form, and what causes rain. (See Exhibit #3)

*See page 253 for addresses.

EXHIBIT #1

TURBULENCE REPORTING CRITERIA TABLE

INTENSITY	AIRCRAFT REACTION	REACTION INSIDE AIRCRAFT	REPORTING TERM-DEFINITION
Light	Turbulence that momentarily causes slight, erratic changes in altitude and/or attitude (pitch, roll, yaw). Report as **Light Turbulence**;* or Turbulence that causes slight, rapid and somewhat rhythmic bumpiness without appreciable changes in altitude or attitude. Report as **Light Chop**.	Occupants may feel a slight strain against seat belts or shoulder straps. Unsecured objects may be displaced slightly. Food service may be conducted and little or no difficulty is encountered in walking.	Occasional – Less than 1/3 of the time. Intermittent – 1/3 to 2/3. Continuous – More than 2/3.
Moderate	Turbulence that is similar to Light Turbulence but of greater intensity. Changes in altitude and/or attitude occur but the aircraft remains in positive control at all times. It usually causes variations in indicated airspeed. Report as **Moderate Turbulence**;* or Turbulence that is similar to Light Chop but of greater intensity. It causes rapid bumps or jolts without appreciable changes in aircraft altitude or attitude. Report as **Moderate Chop**.	Occupants feel definite strains against seat belts or shoulder straps. Unsecured objects are dislodged. Food service and walking are difficult.	**NOTE** 1. Pilots should report location(s), time (GMT), intensity, whether in or near clouds, altitude, type of aircraft and, when applicable, duration of turbulence. 2. Duration may be based on time between two locations or over a single location. All locations should be readily identifiable. EXAMPLES: a. Over Omaha, 1232Z, Moderate Turbulence, in cloud, Flight Level 310, B707. b. From 50 miles south of Albuquerque to 30 miles north of Phoenix, 1210Z to 1250Z, occasional Moderate Chop, Flight Level 330, DC8.
Severe	Turbulence that causes large, abrupt changes in altitude and/or attitude. It usually causes large variations in indicated airspeed. Aircraft may be momentarily out of control. Report as **Severe Turbulence**. *	Occupants are forced violently against seat belts or shoulder straps. Unsecured objects are tossed about. Food service and walking are impossible.	
Extreme	Turbulence in which the aircraft is violently tossed about and is practically impossible to control. It may cause structural damage. Report as **Extreme Turbulence**.*		

* High level turbulence (normally above 15,000 feet ASL) not associated with cumuliform cloudiness, including thunderstorms, should be reported as CAT (clear air turbulence) preceded by the appropriate intensity, or light or moderate chop.

SC/AMS Meeting 7/67

EXHIBIT #2

FORECASTING GUIDE ON TURBULENCE INTENSITY

	DERIVED GUST VELOCITY AND TYPICAL RESPONSE OF MOST AIRCRAFT			FREQUENTLY ASSOCIATED METEOROLOGICAL EVENTS			
		Incremental 2/ Vertical Acceleration					
INTENSITY	Ude 1/	Root Mean Square	Peak	Vertical Wind Shear 3/	Convective Clouds 4/	Surface Winds 5/	Mountain Wave
Light	5 to 20 fps	Less than .2 g	Absolute Value >.2 to .5 g	3-5 kts per 1000 ft	Fair weather cumulus and altocumulus	When surface winds exceed 15 kts and where air is colder than the underlying surface	See Footnote 6/
Moderate	> 20 to 35 fps	.2 to .3 g	Absolute Value >.5 to 1.0 g	6-9 kts per 1000 ft	Thunderstorms, cumulonimbus, and towering cumulus	When surface winds exceed 25 kts or atmosphere is unstable due to strong insolation or cold air advection	See Footnote 6/
Severe	> 35 to 50 fps	>.3 to .6 g	Absolute Value > 1.0 to 2.0 g	10 kts or more per 1000 ft	Mature or rapidly growing thunderstorms and occasionally with cumulonimbus or towering cumulus	Not specified	See Footnote 6/
Extreme	More than 50 fps	Over .6 g	Absolute Value > 2.0 g	Not specified	Severe thunderstorms	Not specified	See Footnote 6/

FOOTNOTES:

1/ **Ude.** The derived gust velocity, Ude, is only a rough approximation of true vertical gust velocity. See Federal Aviation Regulations, Part 23, paragraph 23.341 and Part 25, paragraph 25.341.

2/ **Incremental Vertical Acceleration.** As measured at the center of gravity of an aircraft. For a given intensity of atmospheric turbulence, these accelerations depend on weight, airspeed, and design characteristics of the aircraft. These values are for guidance only and do not indicate precise limits.

3/ **Vertical Wind Shear.** These values (vectors) are statistically typical for a layer 5,000 feet thick as obtained from rawinsonde data encoded for teletypewriter transmissions. Turbulence of these specified intensities is not always present.

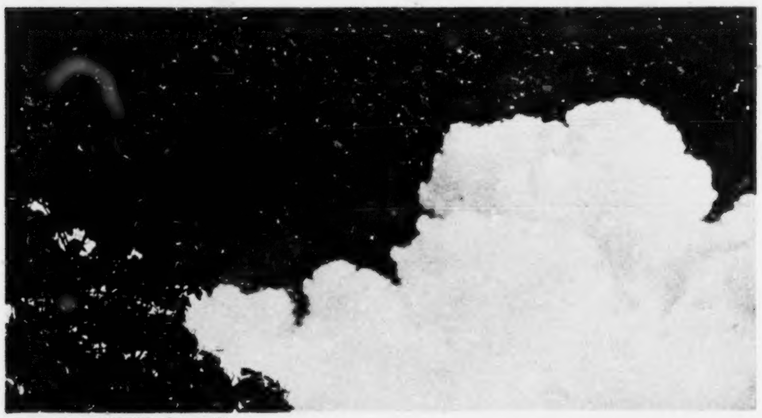
4/ **Convective Clouds.** Turbulence associated with convective clouds may be present in the immediate environment of, as well as in, the cloud systems. Severe turbulence may be present in some portion of any thunderstorm. Extreme turbulence may be present in some portion of any mature or rapidly growing thunderstorm. Superadiabatic lapse rates near the surface also may produce moderate tubulence.

5/ **Surface Winds.** Depends on terrain roughness and stability as well as wind speed. Interactions are often present between low-level convective activity and mechanical turbulence.

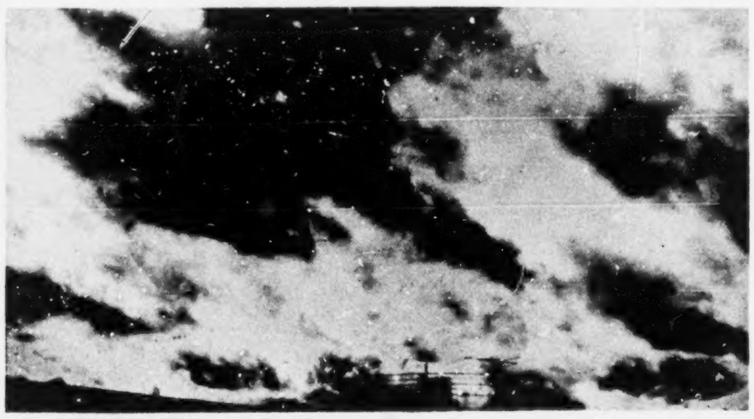
6/ **Mountain Wave.** Moderate or greater turbulence may be found with strong winds generally normal to the mountain ridge, wind speed increasing with height and relatively stable layers. Turbulence is likely at levels near the ridge height, in relatively stable layers and at the tropopause. Turbulence layers may be up to about 5,000 feet thick and may extend 50 to 100 miles downstream. The presence of troughs and jet streams can enhance wave development. Wind-shear turbulence and mountain wave activity may interact to produce variations in turbulence over a wide range of altitudes. Severe or occasionally extreme turbulence may be found in or near rotor clouds and may extend to the ground. Turbulence may be present in mountain waves even though there is insufficient moisture available for the formation of lenticular or rotor clouds.

SC/AMS Meeting 7/67

EXHIBIT #3



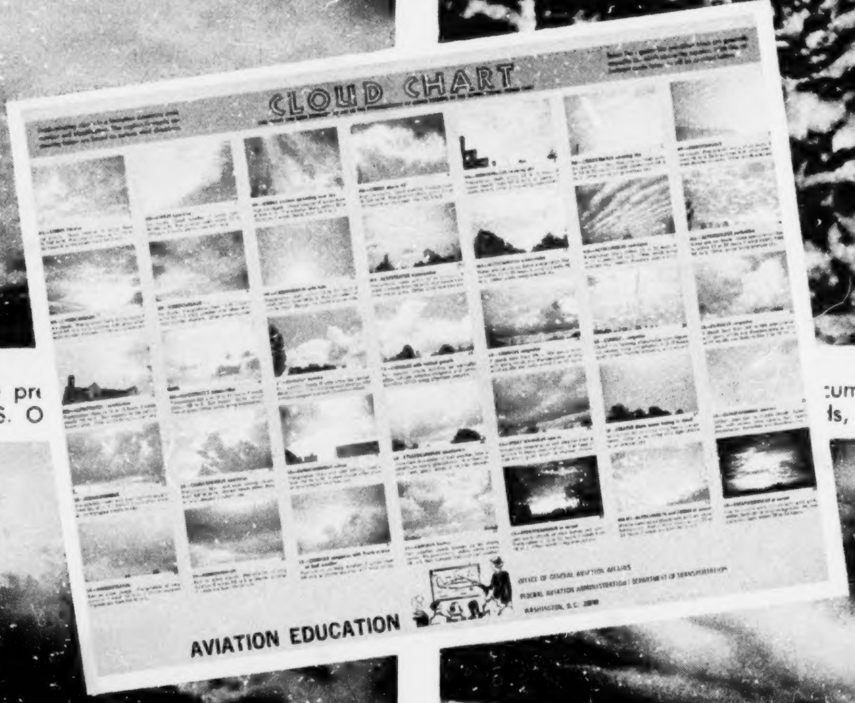
1 **CUMULUS humilis**
Fair weather clouds if they show no vertical development. Can build up and develop into cumulus congestus or cumulonimbus clouds.



2 **ALTOSTRATUS translucidus**
Precipitation likely in 10 to 15 hours if winds steady NE to S. Sun appears to be behind frosted glass. Other winds bring overcast sky.

3 **ALTOCUMULUS translucidus**
Water and ice clouds. Some pr
hours if wind is steady NE to S. O

cumulogenitus usually bring precip-
ds, thunder showers, wind squalls.

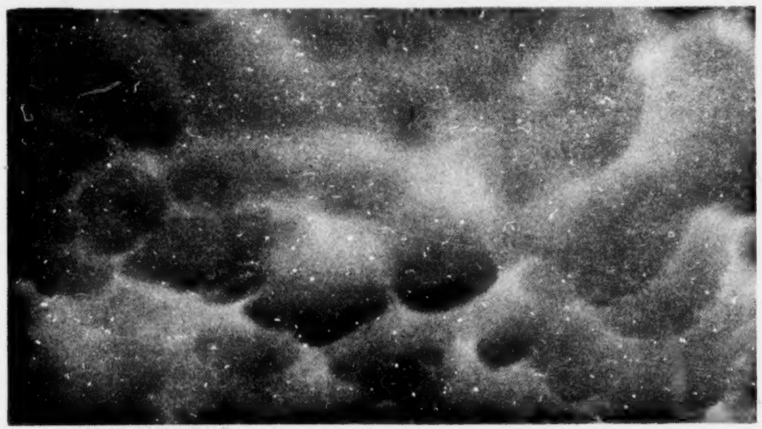


CLOUD CHART

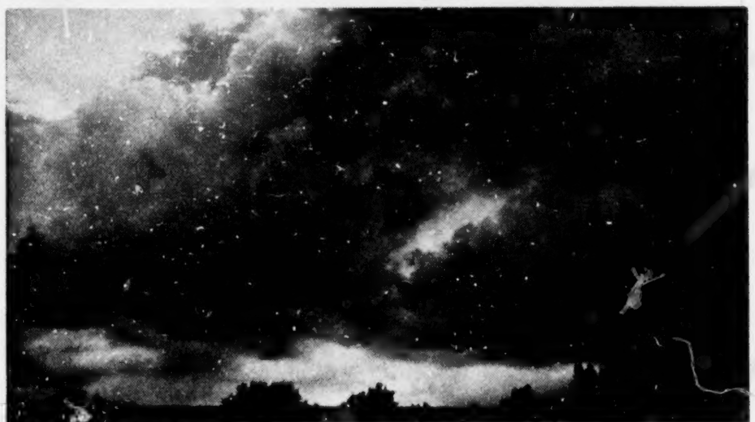
AVIATION EDUCATION

5 **CUMULONIMBUS**
Precipitation likely and soon coming usually from SW W to N. Distant clouds will often show an interesting anvil-shaped cirroform cap.

6 **STRATOCUMULUS opacus**
Immediate threatener of bad weather from a sprinkle to heavy precipitation. If at head of cold front, gusty winds or thunder shower.



7 **CUMULONIMBUS mamma**
Seldom seen low to middle clouds. Associated with severe wind squalls, hail, heavy precipitation, tornadoes and thunderstorms.



8 **CUMULONIMBUS**
Precipitation likely and soon coming usually from SW W to N. Distant clouds will often show an interesting anvil-shaped cirroform cap.

INTRODUCTION

Man walked....over hill and down vale, but around mountains which he could not climb.

Man sailed....on the waterways of the world, but always around protruding land masses.

Man flew....over wooded mountain and precipitous canyon, over flooded river, burning desert, and polar ice cap.

To find his way, man looked into the heavens and found the stars to guide him. He looked within and created electronic devices to direct his path. He learned to navigate almost as unerringly as Bryant's waterfowl.*

"There is a Power whose care
Teaches thy way along that pathless coast -
The desert and illimitable air -
Lone wandering, but not lost."

And man reflected that he might chart a course throughout life without error.

"He who, from zone to zone,
Guides through the boundless skies thy certain flight,
In the long way that I must tread alone,
Will lead my steps aright."

---

* "To a Waterfowl" by William Cullen Bryant

TO THE TEACHER

The Navigation unit in the Aeronautical Science course is intended to help the student to accomplish the following goals:

1. To increase map-reading skills.
2. To deepen scientific understanding of laws and principles which apply to navigation.
3. To improve mathematical skills through solving complex navigational problems.
4. To gain greater understanding of geographic concepts.
5. To realize the international significance of great circle routes.
6. To improve language skills through the use of radio transmission and through the mastery of an enlarged vocabulary.
7. To recognize both civilian and military career opportunities in cartography, aerial photography in map-making, and navigation.

And for the student who becomes a pilot, this course is intended to help him:

8. To understand the principles of cross-country flying.
9. To know basic flight planning procedure.

References throughout the course outline are to sources listed at the back of the unit on the page entitled "Resources."

If flight indoctrination is part of the Aeronautical Science course, it is desirable to schedule the cross-country flight at the conclusion of this unit on navigation. (See the unit on Flight Indoctrination.)

It is recommended that problem-solving be stressed. Ample practice in the solution of wind-triangle problems should be given prior to the introduction of problem-solving on the computer; students should understand that solution on the computer is purely a transfer of the skill and method developed in triangle solution.

UNIT OUTLINE

I. The Earth

- A. Location relative to sun and planets
- B. Size relative to other planets.
- C. Shape.
- D. Basic movements.
  - 1. Rotation on own axis.
  - 2. Revolution around sun.
    - a. Equinox.
    - b. Solstice.
- E. Latitude and sun relationships.
  - 1. Measured N and S, equator to poles, 0° to 90°.
  - 2. Major lines of latitude.
- F. Longitude and time relationships.
  - 1. Measured E and W, Prime Meridian to International Date Line, 0° to 180°.
  - 2. Date change at International Date Line: Monday in U. S. - Tuesday in Japan.
  - 3. 360 : 24 hours = 15 : 1 hour; 15 = 1 hour; 1 = 4 min.of time.
  - 4. Time zones in United States.
  - 5. Zulu time and GMT.
- G. Great circle routes.
  - 1. Comparison to rhumb line routes.
  - 2. 1' on great circle = 1 nautical mile.

II. Projections.

- A. Distortion.
  - 1. Shape.
  - 2. Size.
  - 3. Relationships.
- B. Types.
  - 1. Conic (Lambert conformal conic).
  - 2. Polyconic.
  - 3. Cylindrical (Mercator).
    - a. Transverse Mercator.
    - b. Oblique Mercator.

NASA,
The Shapes of Tomorrow, p. 21.
Demonstrate with a planetarium.
Student makes mobile of solar system.

Shine desk lamp on globe in semi-dark room.

Van Sickle, pp. 543-544.

Misenhimer - Navigation Unit.

U. S. Navy,
Time Zone Chart of the World

Nautical mile = 6,076.1 feet.
Knot is nautical mile/hour (speed).

Use 1/2 grapefruit skin to illustrate a hemisphere. Force out flat. Skin will stretch and tear. This is distortion.

Bauer, pp. 14-15

Deetz,
Elements of Map Projection
Film: "Measuring and Mapping the World."

4. Gnomic.

Van Sickle, pp. 545-547.

5. Stereographic.
6. Others.

Van Deventer, pp. 296-298.

III. Aeronautical Charts and Scales

U. S. Coast & Geodetic Survey, outdated charts.

A. Sectional - 8 miles/inch.

B. World Aeronautical Charts (WAC - ONC outside U.S.) - 16 miles/inch.

Van Deventer, pp. 299-301.
Van Sickle, pp. 547-551.

C. Jet chart - 32 miles/inch.

D. Aeronautical planning chart - 32 miles/inch.

E. Local aeronautical chart - 4 miles/inch (congested area).

F. GNC chart - 80 miles/inch (Air Force planning chart).

IV. Map Reading

A. Topographic information.
1. Drainage.
2. Culture.
3. Relief.

B. Aeronautical data.

Sanderson Navigation Record and Film Strip "A."
"Aerial Navigation-Map Reading"
"Highway in the Sky"

1. Airports and facilities.
2. Airway navigation lights.
3. Radio range stations and omniranges.
4. Variation

Van Deventer, pp. 301-302.

a. Isogonic lines.
b. True north.
c. Magnetic north.

See a physics laboratory manual under Kinematics--Resolution of Forces for experiments on navigation.

5. Miscellaneous
a. Caution area.
b. Restricted area.
c. Prohibited area.

C. Legend.
1. Projection.
2. Scale.
3. Data on reverse side.

D. Correct method of folding.

V. Navigational Instruments

Sanderson Instrument Record and Film Strip - See "B"

A. Minimum instruments.

1. Clock.	
2. Airspeed indicator - pressure instrument.	
a. Correction for pressure-altitude.	
b. Correction for temperature.	
c. Mach meter (supersonic aircraft).	
3. Magnetic compass.	
a. Floating type.	
b. British or ship type.	
c. Acceleration error.	
d. Northerly turn error.	
e. Deviation.	Van Deventer, p. 302.
f. Compensating on compass rose.	
4. Turn-and-bank indicator (needle-and-ball) (turn-and-slip).	Demonstration of centrifugal and centripetal forces.
a. Needle indicates degree of bank.	
b. Ball indicates coordination of controls.	(Bucket of water spun at arm's length will not spill.)
5. Altimeter - aneroid barometer.	
a. Correction for temperature.	
b. Correction for pressure.	
c. Indicated-, calibrated-, pressure-, true-, absolute-, and density-altitude.	
B. Additional instruments.	
1. Gyro compass.	Sanderson Instrument Record and Film Strip "C".
2. Vertical speed indicator.	
3. Gyro horizon	
4. Drift sight (used over water and in military aircraft).	Use toy gyroscope to explain theory of gyro-instruments.
5. Radio instruments (See Radio Navigation).	
VI. Methods of Navigation	
A. Pilotage - landmark to landmark.	Van Deventer, p. 295.
B. Astrogation (celestial).	Plan field trip to observatory.
1. Celestial charts.	NASA, The Shapes of Tomorrow
2. Air almanac.	Film: "How Many Stars."
3. Sextant.	
C. Radio and radar (See Radio Navigation.)	
D. Dead reckoning.	Sanderson Navigation Records and Film Strips "B" and "C."
1. Plot track on chart as straight-line or series of straight lines.	Film: "Primary Pilot Navigation."

2. Measure the true course (TC) on meridian nearest center of each leg.	Van Sickle, pp. 551-561.
3. Plot wind triangle. a. Measure wind correction angle (WCA).	Film: "Wind and the Navigator--Wind Theory."
b. Add right wind (subtract left) to find true heading (TH).	Exam-O-Gram 27. TC wind drift = TH TH variation = MH MH deviation = CH
4. Determine magnetic variation (Isogonic lines). a. Add westerly variation (subtract easterly) to find magnetic heading (MH).	Van Deventer, p. 302-303.
b. "East is least, west is best." c. In western U. S., variation is easterly; in eastern U. S., variation is westerly.	
5. Check compass card for deviation. Add westerly variation (subtract easterly) to find compass heading (CH).	Have students become proficient with wind triangles before introducing computer.
6. Select check points, distance to, and ETA.	
7. Preflight planning. a. Study chart along plotted track.	Film: "Wind and the Navigator--Preflight Planning."
b. Note aids to navigation; radio frequencies and identifications; AIM and NOTAMS.	Film: "The Pilot and Air Traffic Control" Film: "Air Traffic Control Procedures."
c. Check weather: winds aloft, and sunset for daylight flights.	Visit air traffic control tower and FAA flight service station.
d. Fuel consumption each leg. e. Weight and balance each leg. f. ETA each leg.	Duplicate sample flight plan forms.
g. File flight plan in person or by telephone; by radio when other means impossible.	Have students make flight plans for various theoretical cross-country flights.
8. Special navigation problems. a. Effect of climb and descent. b. Off-course corrections.	Exam-O-Gram 18. Film: "Where Am I?"
c. Radius of action. d. Alternate airport. e. Interception.	Film: "Wind and the Navigator" - Parts c and d.
9. Post flight procedure: Close flight plan.	
10. Limitations of dead-reckoning.	
VII. Flight Computer	Van Sickle, pp. 562-568.
A. Conversions	Van Deventer, p. 313.
1. Nautical miles to statute miles.	

2. Knots to miles-per-hour.
3. Centigrade to Fahrenheit.

B. Problems.
   1. Time enroute.
   2. Ground speed.
   3. Distance traveled.
   4. Actual airspeed (CAS to TAS).
   5. Actual altitude (true altitude).
   6. Density of the air.
   7. Fuel required.
   8. Rate of fuel consumption.
   9. Rate of climb and descent.
   10. Off-course problems.

VIII. Radio Navigation

A. Very high frequency omnirange (VOR).
   1. VOR signals.
      a. Emissions.
      b. Directional.
      c. Line-of-sight.
      d. Accuracy.
   2. VOR equipment (aircraft).
      a. Aircraft receiver.
      b. Course deviation indicator (CDI)
      c. Omni bearing selector (OBS)
      d. "To" - "From" indicator.
   3. VOR radials.
      a. Radials like spokes of a wheel.
      b. Always "Out From."
      c. Radials are like streets.
         1. What direction are you going on the street?
         2. Learn reciprocals (180°)
         3. Flying the radials.
      d. Interception of VOR radials.
         1. Know the compass.
         2. Intercept inbound or outbound.
         3. Angle of interception.
      e. Position fixing.
         1. Taking cross bearings.

Recommend use of two Sanderson transparencies on an overhead projector to teach use of E6B; the transparencies have moving parts.

Recommend use of Sanderson Flight Computer Records and Film Strips, A, B and C.

Warning to students: Computers left in sun, in hot car or airplane, or exposed to heat will warp and become unusable.

Expendable computers (without the wind side) made of plastic coated paper are available from distributors of aviation gasoline from Standard Oil.

Work all previous wind drift problems on the computer.

Radio Navigation, Sanderson Film Co. Booklet, pp. A-2 thru A-4.

FAA, Private Pilot Exam.Guide, Ch.4

Radio Navigation, Sanderson Film Co. Booklet, p. A-4 (Fig. A-11).

Van Sickle, p. 582.

Sanderson Magnetic OMNI Board.

Van Sickle, pp. 585-587.

Radio Navigation, Sanderson Film Co. Booklet, p. A-7.

Radio Navigation, Sanderson Film Co. Booklet, p. A-6.

2. Plotting line of position (LOP).	Radio Navigation, Sanderson Film Co. Booklet, p. A-13.
3. Time and distance problems.	
a. Simple wing tip solution.	
b. Double the angle solution.	Van Sickle, p.589.
4. Evaluation.	
a. Advantages.	Van Deventer, p. 334.
1. Not affected by most weather.	
2. Accuracy.	
3. Easy-to-fly radials.	Radio Navigation, Sanderson Film Co. Booklet, p. A-1.
4. Not affected by diurnal changes.	
b. Disadvantages.	Radio Navigation, Sanderson Film Co. Booklet, p. A-15.
1. Line-of-sight only for accuracy.	
2. Not usable in mountains at low altitudes.	
3. Heavy precipitation static renders it unusable.	
B. Automatic direction finder (ADF).	
1. Frequency range.	Radio Navigation, Sanderson Film Co. Booklet, p. B-7.
a. 200 - 415KC	
b. Standard broadcast band.	
2. Application of ADF.	
a. Homing	Van Sickle, p. 593.
b. Tracking to the station.	
c. Instrument approaches.	
d. Position fixing.	
e. Time and distance problems.	
f. Interception of bearings.	Van Sickle, pp. 591-599.
3. Glossary of terms.	
a. Bearings.	Van Sickle p. 590.
b. Relative bearing.	
c. Radio beacon.	
d. Compass locator.	FAA, Airman's Information Manual, Part 1, ref. ILS components.
4. Advantages.	
a. Use to navigate to many towns not served by navigational facilities, only local broadcast station.	
5. Disadvantages.	
a. Use in the off-airway navigation.	
b. Weather sometimes a deterring factor.	

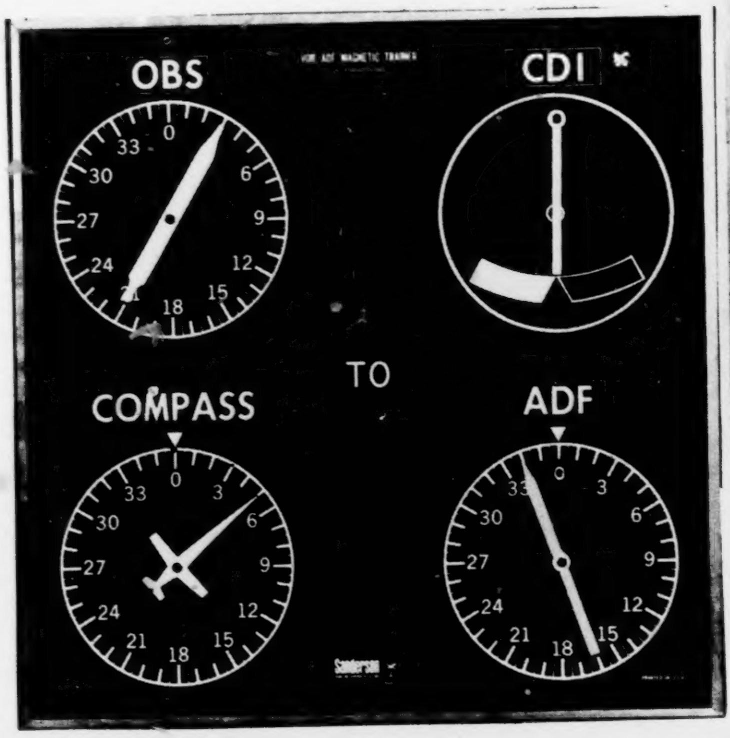
C. Distance measuring equipment. (DME)
  1. Frequency: (VHF)
  2. Measurement.
    a. Slant range distance.
    b. Read-out, Odometer or digital.
  3. Accuracy.
    a. Within ± 600 ft.+2%
  4. Required equipment in operation above 24,000 ft.

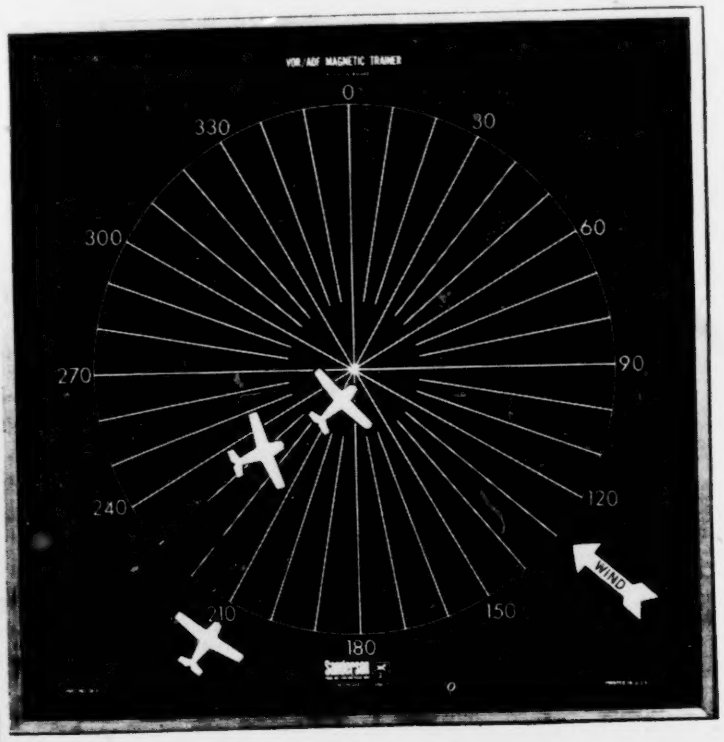
Van Sickle, p.222.

D. Transponder: IFF equipment.
  1. Airborne radar interrogator.
  2. Interrogation modes.
    a. Mode A, used to identify aircraft, same as military mode 3.
    b. Mode C automatic altitude interrogation. (not in effect universally) 1290 code capability.
    c. IFR codes, as designated by ATC 0100 etc.
    d. VFR codes, 0600 for VFR flights to 24,000 ft. and 0700 for VFR flight above 24,000 ft.
    e. Emergency code 7700.
    f. Classified code of 0000 is NEVER TO BE USED.

Bendix Radio Division Avionics Products TPR-600 Transponder System Instruction Manual, Baltimore, Maryland 21204 or Burbank, California.

FAA, Airman's Information Manual, p. 1-64.


OBS
CDI
TO
COMPASS
ADF
33
30
27
24
21
18
15
12
9
6
3
0
Sanderson


VOR/ADF MAGNETIC TRAINER
0
30
60
90
120
150
180
210
240
270
300
330
WIND
Sanderson

The Sanderson VOR/ADF Trainer offers the most practical way for the instructor to demonstrate, and the student to understand, the relationship of aircraft radio navigation instrument readings to the exact position or heading of the aircraft under any assumed conditions and situations.

The CDI instrument is also used in conjunction with the Instrument Landing (ILS). (See ILS chart on p. 65).

RESOURCES

Materials:

Globe
Charts (Sectional, Local Aeronautical, World Aeronautical)
Computer & Plotter (or ruler and protractor). Inexpensive plotters and computers are available from Sanderson Films, Inc., 1501 South West Street, Wichita, Kansas 67213; Aero Products Research, Inc., 11811 Teale Street, Culver City, California 90230; A.V.Company, 2795 E. Exposition, Denver, Colorado 80222; and Kane Aero Company, 8000 S. Lyndale Avenue, Minneapolis, Minnesota 55420.

Textbooks:

Bauer, Hubert A., Globes, Maps, and Skyways. New York: Macmillan (Air Education Series).
Deetz, Charles H. and Oscar S.Adams, Elements of Map Projection. C&GS Publication No. 68, U.S.Coast & Geodetic Survey, Environmental Science Services Administration, Washington, D.C. 20234, 1964. $2.75
Lyon, Thoburn C., Practical Air Navigation, 10th edition, Denver, Colorado: Jeppesen & Company
NASA, The Shapes of Tomorrow. Washington, D.C.: Supt. of Documents, Government Printing Office, Washington, D.C. 20402. $1.50.
Van Deventer, C.N., An Introduction to General Aeronautics. American Technical Society, 1965.
Van Sickle, Neil D., Modern Airmanship, 3rd edition, Princeton, N.J.: Von Nostrand, 1966.

Reference Books and Information:

Above and Beyond: The Encyclopedia of Aviation and Space Sciences, Chicago: New Horizons Publishers, Inc., 1968.
Bernardo, James V., Aviation and Space in the Modern World, New York: E.P. Dutton & Co., 1968.
*Federal Aviation Administration, FAA Advisory Circulars:
    00-2 "Advisory Circular Checklist," (Latest Revision)
    61-23 "Private Pilots' Handbook of Aeronautical Knowledge," (5-27-66). ($2.75 GPO).
    61-32 "Private Pilot Written Examination Guide," (8-15-67). ($1.75 GPO) GPO).
    90-19 "Use of Radar for the Provision of Air Traffic Control Services," (10-29-64).
    90-32 "Radar Capabilities and Limitations," (8-15-67).
    91-15 "Terrain Flying." (2-2-67). ($0.55, GPO).
    170-3B "Distance Measuring Equipment (DME)," (11-8-65).
FAA, Airman's Information Manual." (Pt.1,$4.00; Pt.2,$4.00; Pt.3,$20.00)
FAA, VFR Exam-)-Grams," Flight Standards Service, 5300 South Portland, Oklahoma City, Oklahoma, 73119. Free.
Institute of Aviation, Fundamentals of Aviation and Space Technology, Urbana, Ill.: Univ. of Illinois, 1968. $2.50.
Jeppeson & Co., Dead Reckoning, PD 105; VOR & DME, PD 107; In-flight Recording, Tower Communications, No. RTC, Denver.
Langewiesche, Volfgang, Stick and Rudder, New York: McGraw-Hill.
Misenhimer, Ted G., Aeroscience, Culver City: Aero Products Research, Inc., 1969
Sanderson Films, Inc., Aviation Fundamentals, Wichita, Kansas, 1967.
Simonson, Leroy, Private Pilot Exam Guide, Inglewood, California $5.00

* See page 244 for address.

Films:

*Federal Aviation Administration:
"A Traveler Meets Air Traffic Control," (FA-102). 1963, Color, 33 Min.
"This Is VORTAC," (FA-104). 1959, B/W, 16 Min.
"Using the Airspace: Navigation and Communications," (FAC-122. 1966, Color, 20 Min. Produced by AOPA Foundation.
"One Eye on the Instruments," (FA-209), 1962, Color, 15 ½ Min.
"Private Pilot," (FA-211). 1963, Color, 15 Min.
"Fundamentals of Approach Control," (ICAO-7), B/W, 19 Min.

*United States Air Force:

FR 165	"Measuring and Mapping the World."
SFP 386	"Highway in the Sky." Color, 33 Min.
SFP 649	"How Many Stars."
SFP 1128	"Where Am I?"
TF 1-3460	"Aerial Navigation - Map Reading." B/W, 21 Min.
TF 1-5206a	"Wind and the Navigator - Wind Theory." Color, 53 Min.
TF 1-5206b	"Wind and the Navigator - Preflight Planning." Color, 53 Min.
TF 1-5206c	"Wind and the Navigator." Color, 53 Min.
TF 1-5206d	"Wind and the Navigator." Color, 53 Min.
TF 1-4990	"Primary Pilot Navigation." Color, 27 min.
TF 1-5041	"The Pilot and Air Traffic Control." B/W, 30 Min.
TF 1-5350	"Air Traffic Control Procedures." B/W, 30 Min.

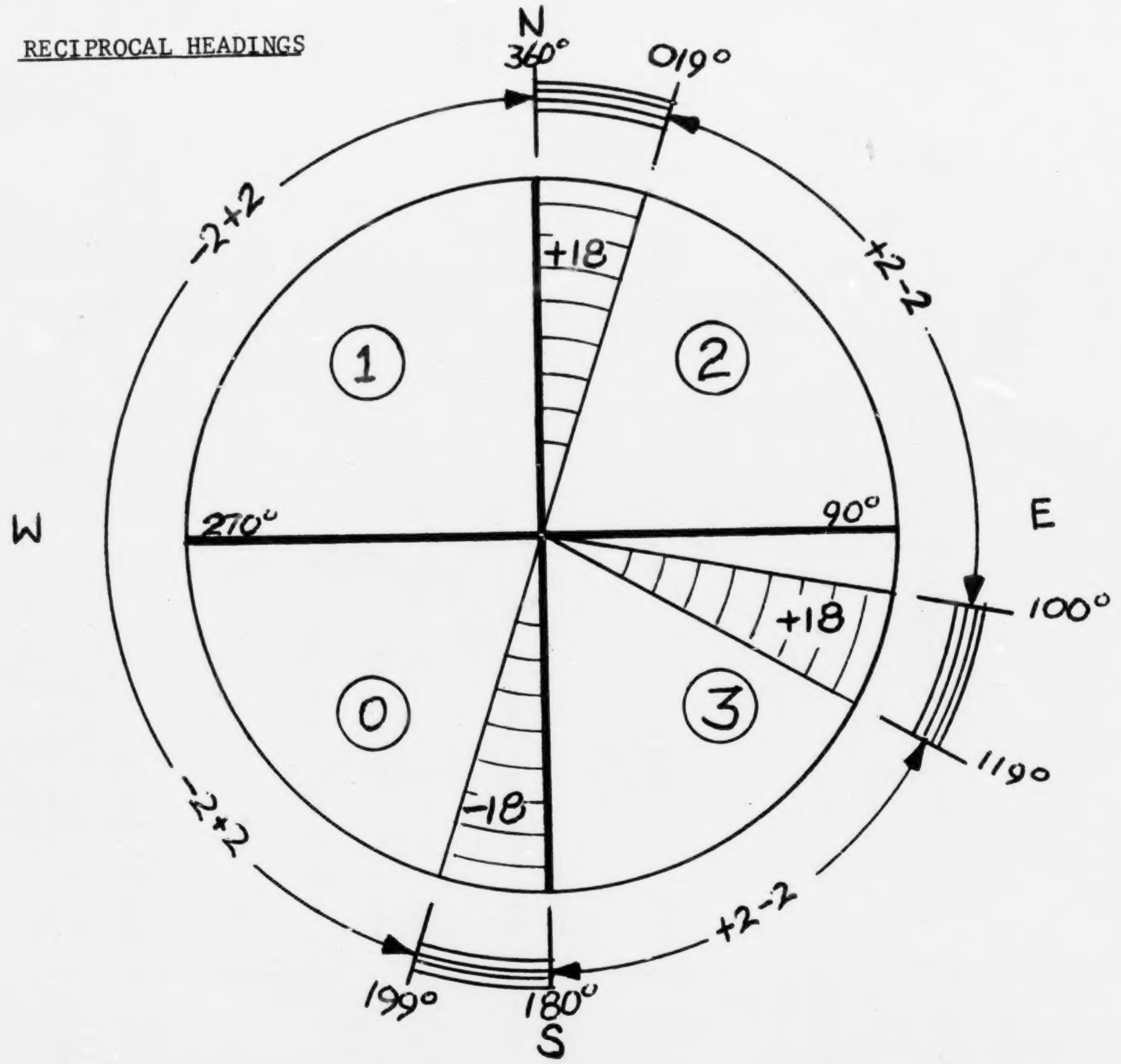
*Note: Refer to List of Film Producers and Distributors in back of Course of Study for addresses. (See pages 233 and 234)

Other Aids:

U. S. Coast & Geodetic Survey, Distribution Division, Rockville, Md., 20852. Outdated aeronautical charts distributed free upon request.
*Jeppesen & Company, Denver, Colorado, Navigation and transparencies.
*Sanderson Films, Inc., Wichita, Kansas. E6B Computer, Radio Navigation, and transparencies. Navigation, Records, and Filmstrips, A, B, and C. Magnetic Omni Board, classroom demonstrator.
U. S. Navy, Time Zone Chart of the World, U. S. Government Printing Office, Washington, D. C. 20402 ($1.00)

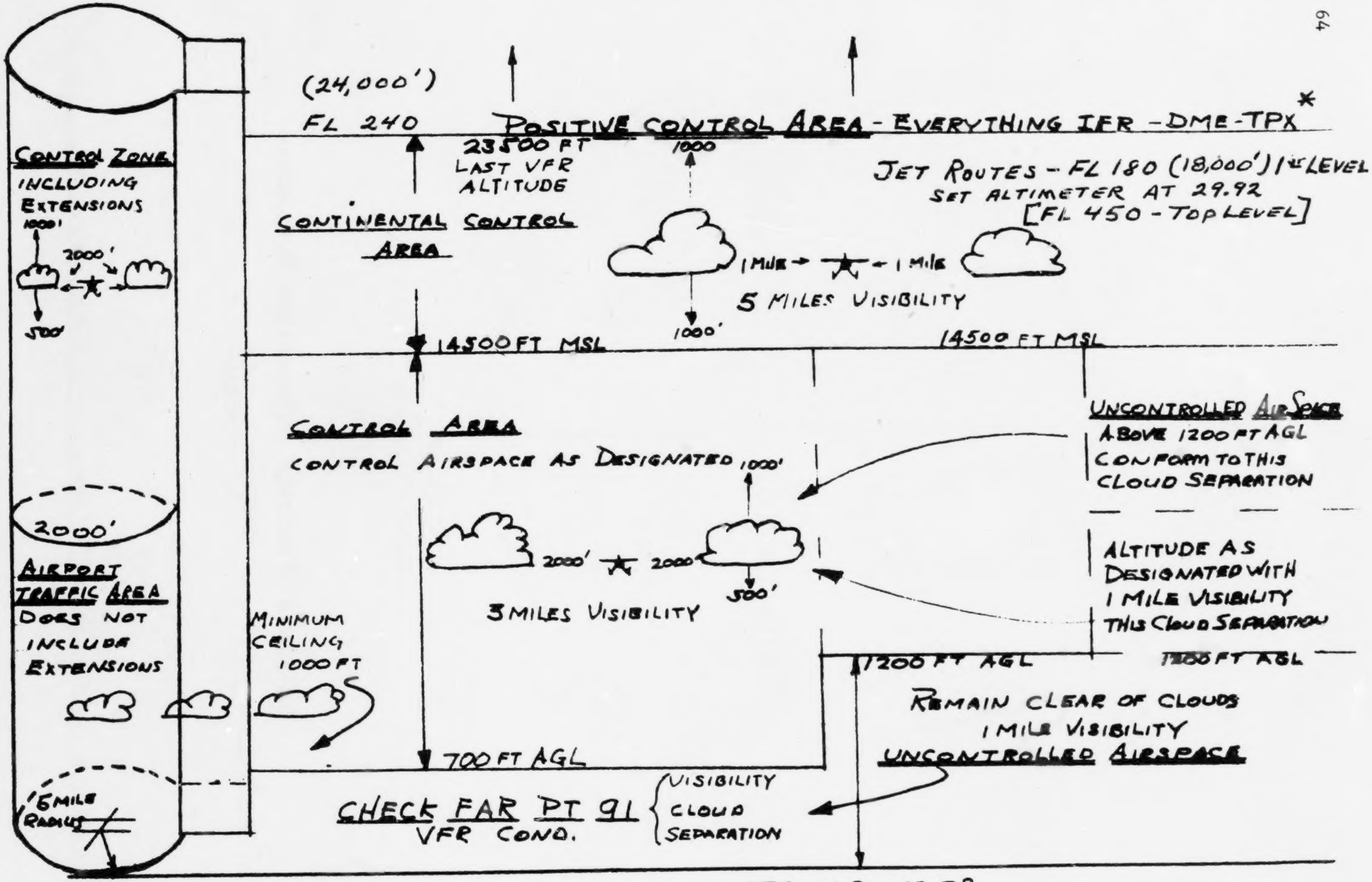
*See page 253 for addresses.

RECIPROCAL HEADINGS


N
360°
019°
-2+2
+2-2
+18
1
2
W
270°
90°
E
+18
100°
0
3
119°
-18
-2+2
+2-2
199°
180°
S

	HEADING	FORMULA	APPLICATION		RECIPROCAL
EXAMPLES	288°	-2+2	288 -2+2	=	108°
	192°	-18	192 -18	=	012°

HEADING IN QUADRANT #3 RESULTS IN A RECIPROCAL BEGINNING IN #3


(24,000')
FL 240
POSITIVE CONTROL AREA - EVERYTHING IFR - DME-TPX *
23500 FT
LAST VFR
ALTITUDE
1000
JET ROUTES - FL 180 (18,000') 1st LEVEL
SET ALTIMETER AT 29.92
[FL 450 - TOP LEVEL]
CONTROL ZONE
INCLUDING
EXTENSIONS
1000'
2000'
500'
CONTINENTAL CONTROL
AREA
1 MILE
1 MILE
5 MILES VISIBILITY
1000'
14500 FT MSL
14500 FT MSL
CONTROL AREA
CONTROL AIRSPACE AS DESIGNATED
1000'
UNCONTROLLED AIRSPACE
ABOVE 1200 FT AGL
CONFORM TO THIS
CLOUD SEPARATION
2000'
2000'
2000'
500'
3 MILES VISIBILITY
ALTITUDE AS
DESIGNATED WITH
1 MILE VISIBILITY
THIS CLOUD SEPARATION
AIRPORT
TRAFFIC AREA
DOES NOT
INCLUDE
EXTENSIONS
MINIMUM
CEILING
1000 FT
1200 FT AGL
1200 FT AGL
REMAIN CLEAR OF CLOUDS
1 MILE VISIBILITY
UNCONTROLLED AIRSPACE
700 FT AGL
5 MILE
RADIUS
CHECK FAR PT 91
VFR COND.
VISIBILITY
CLOUD
SEPARATION

* DISTANCE MEASURING EQUIPMENT — TRANSPONDER

ILS
(FAA Instrument Landing System)
STANDARD CHARACTERISTICS AND TERMINOLOGY

ILS approach charts should be consulted to obtain variations of individual systems.

VHF LOCALIZER

108.1 to 111.9 MHz odd tenths only. Radiates about 100 watts. Horizontal polarization. Modulation frequencies 90 and 150 cycles. Modulation depth on course 20% for each frequency. Code identification (1020 cycles, 5%) and voice communication (modulated 50%) provided on same channel. At some localizers, where terrain (siting) difficulties are encountered, an additional antenna (slotted waveguide type) provides the necessary course straightness.

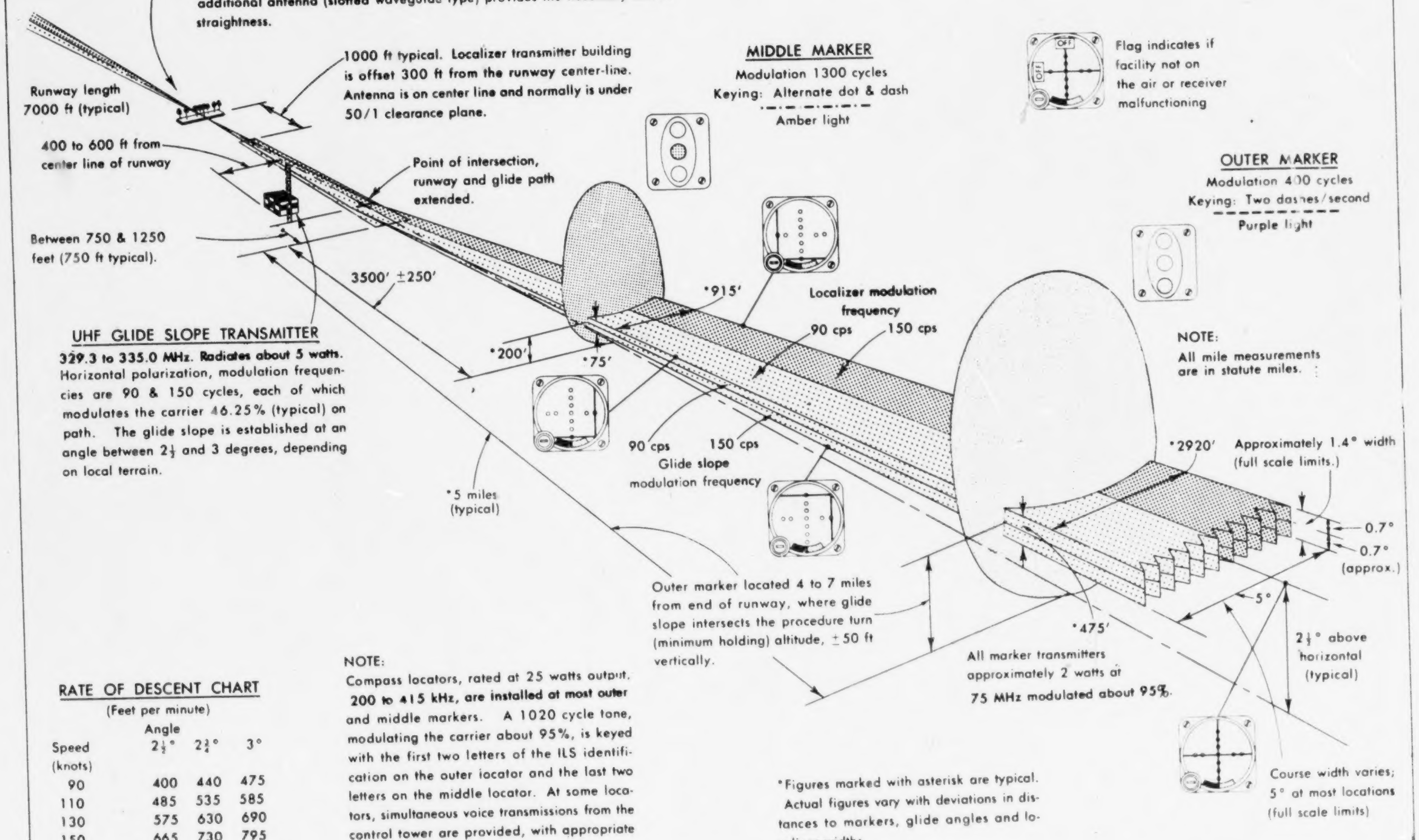
1000 ft typical. Localizer transmitter building is offset 300 ft from the runway center-line. Antenna is on center line and normally is under 50/1 clearance plane.

MIDDLE MARKER

Modulation 1300 cycles
Keying: Alternate dot & dash
Amber light

OUTER MARKER

Modulation 400 cycles
Keying: Two dashes/second
Purple light


Runway length
7000 ft (typical)
400 to 600 ft from center line of runway
Between 750 & 1250 feet (750 ft typical).
Point of intersection, runway and glide path extended.
3500′ ±250′
*200′
*75′
*915′
Localizer modulation frequency
90 cps
150 cps
90 cps
150 cps
Glide slope modulation frequency
*5 miles (typical)
Flag indicates if facility not on the air or receiver malfunctioning
OFF
*2920′
Approximately 1.4° width (full scale limits.)
0.7°
0.7°
(approx.)
5°
2½° above horizontal (typical)
*475′
Course width varies; 5° at most locations (full scale limits)

NOTE:
All mile measurements are in statute miles.

Outer marker located 4 to 7 miles from end of runway, where glide slope intersects the procedure turn (minimum holding) altitude, ± 50 ft vertically.

All marker transmitters approximately 2 watts at 75 MHz modulated about 95%.

UHF GLIDE SLOPE TRANSMITTER

329.3 to 335.0 MHz. Radiates about 5 watts. Horizontal polarization, modulation frequencies are 90 & 150 cycles, each of which modulates the carrier 46.25% (typical) on path. The glide slope is established at an angle between 2½ and 3 degrees, depending on local terrain.

RATE OF DESCENT CHART

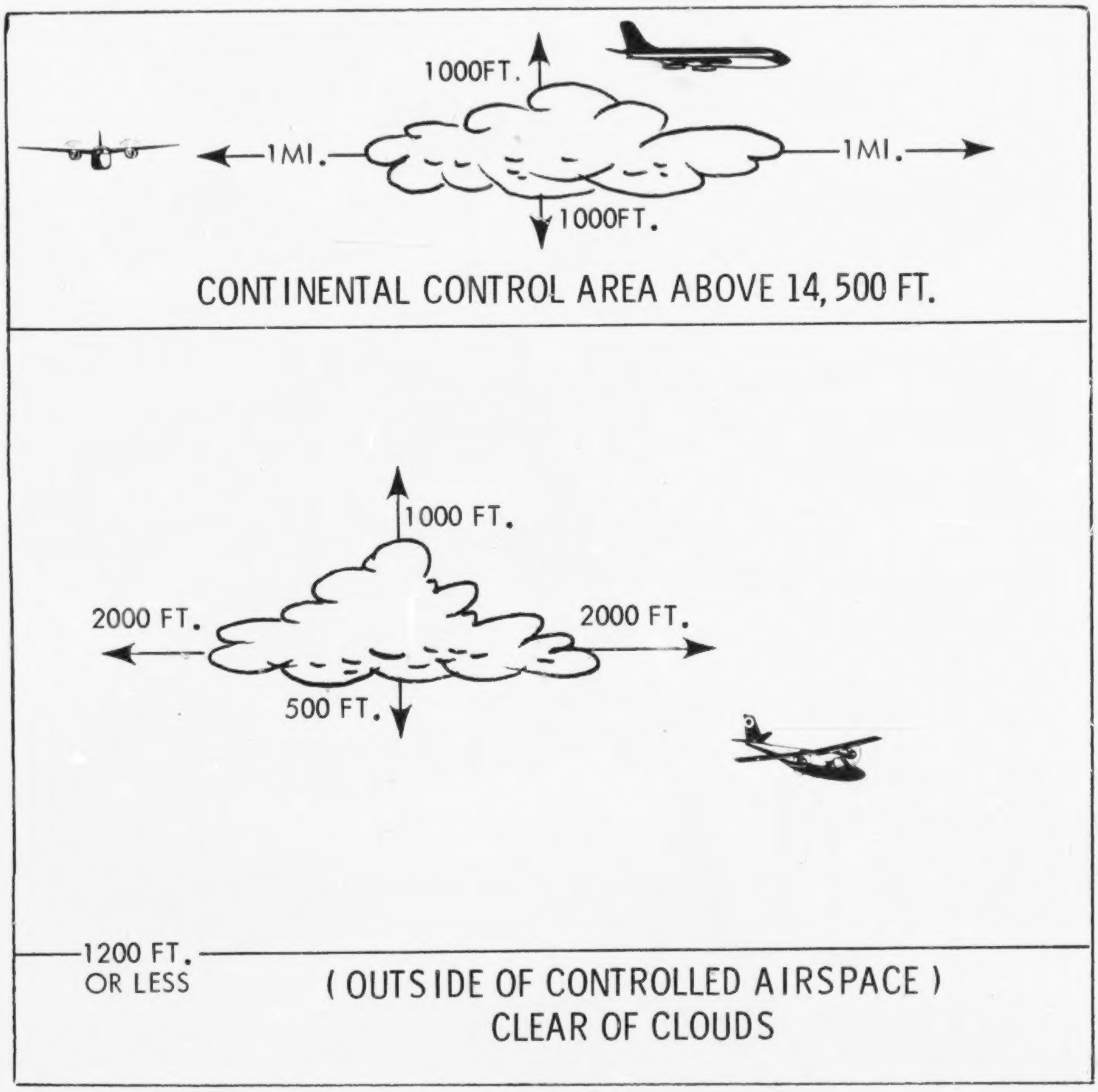
(Feet per minute)

Speed (knots)	Angle 2½°	2¾°	3°
90	400	440	475
110	485	535	585
130	575	630	690
150	665	730	795
160	707	778	849

NOTE:
Compass locators, rated at 25 watts output, **200 to 415 kHz, are installed at most outer** and middle markers. A 1020 cycle tone, modulating the carrier about 95%, is keyed with the first two letters of the ILS identification on the outer locator and the last two letters on the middle locator. At some locators, simultaneous voice transmissions from the control tower are provided, with appropriate reduction in identification percentage.

*Figures marked with asterisk are typical. Actual figures vary with deviations in distances to markers, glide angles and localizer widths.

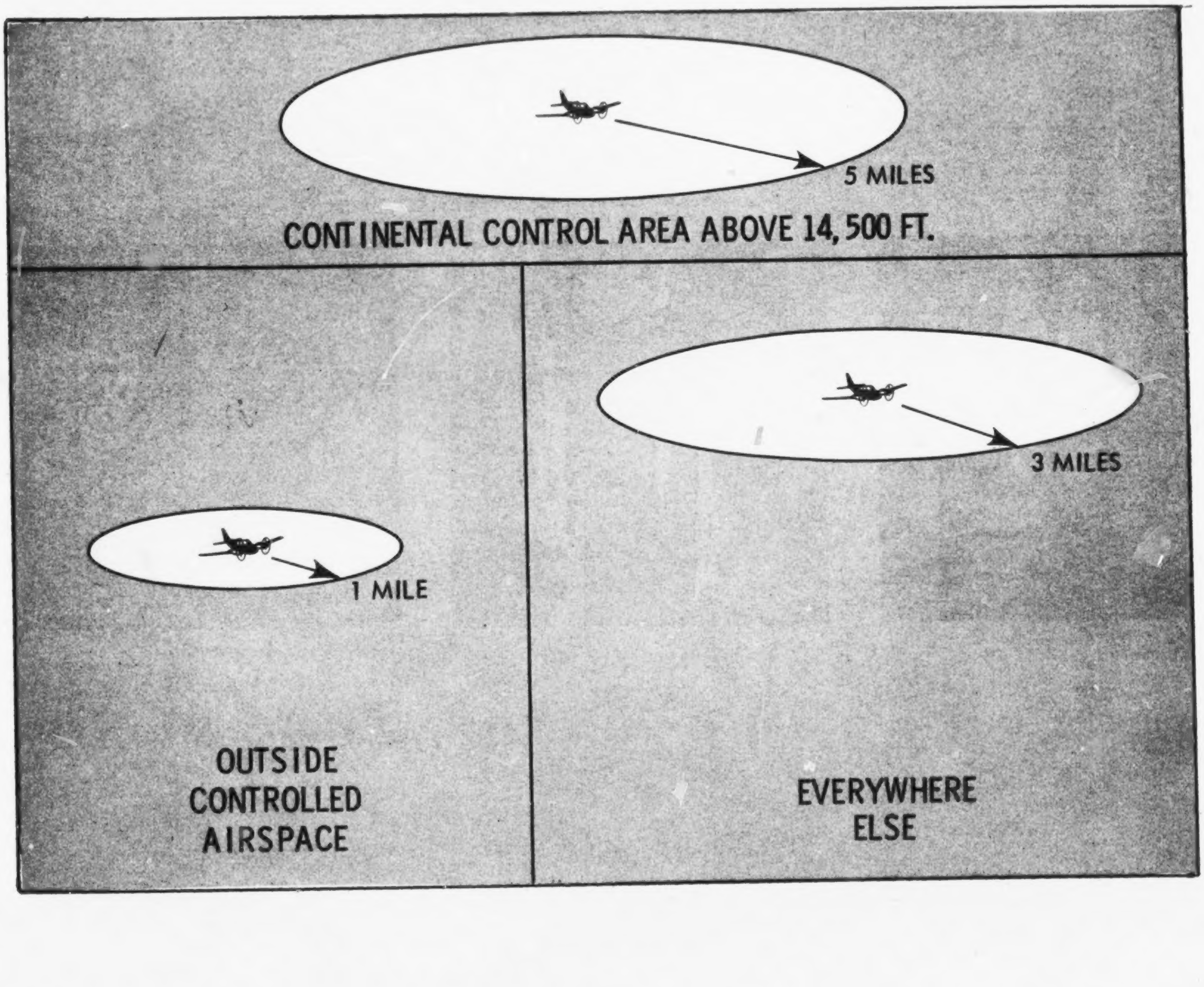
EXHIBIT I


1000FT.
1MI.
1MI.
1000FT.
CONTINENTAL CONTROL AREA ABOVE 14,500 FT.
1000 FT.
2000 FT.
2000 FT.
500 FT.
1200 FT. OR LESS
(OUTSIDE OF CONTROLLED AIRSPACE)
CLEAR OF CLOUDS

Minimum Distances from Clouds - VFR

67/68

EXHIBIT II


5 MILES
CONTINENTAL CONTROL AREA ABOVE 14,500 FT.
1 MILE
OUTSIDE CONTROLLED AIRSPACE
3 MILES
EVERYWHERE ELSE

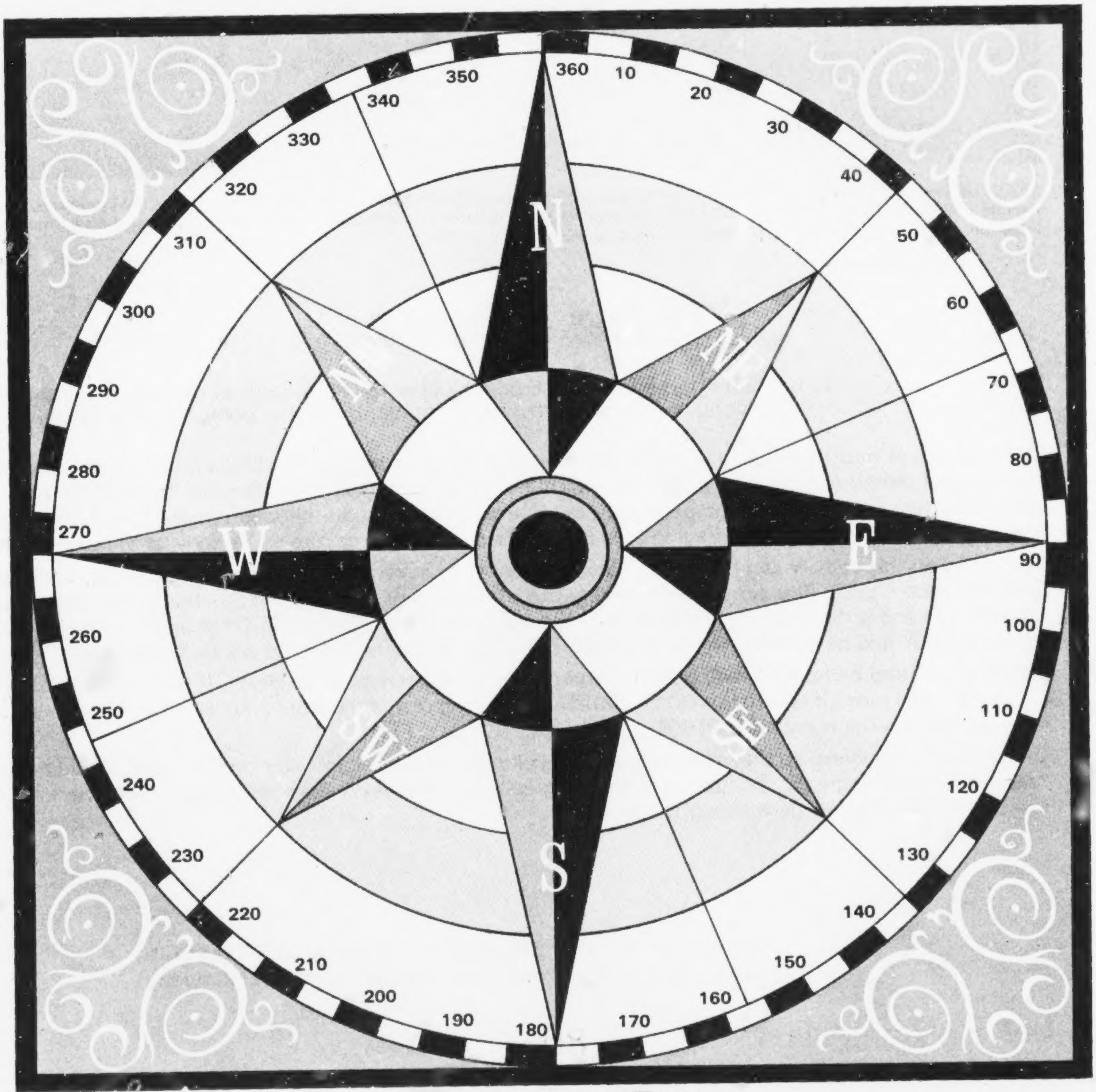
Minimum Visibility - VFR

The Compass Rose Game

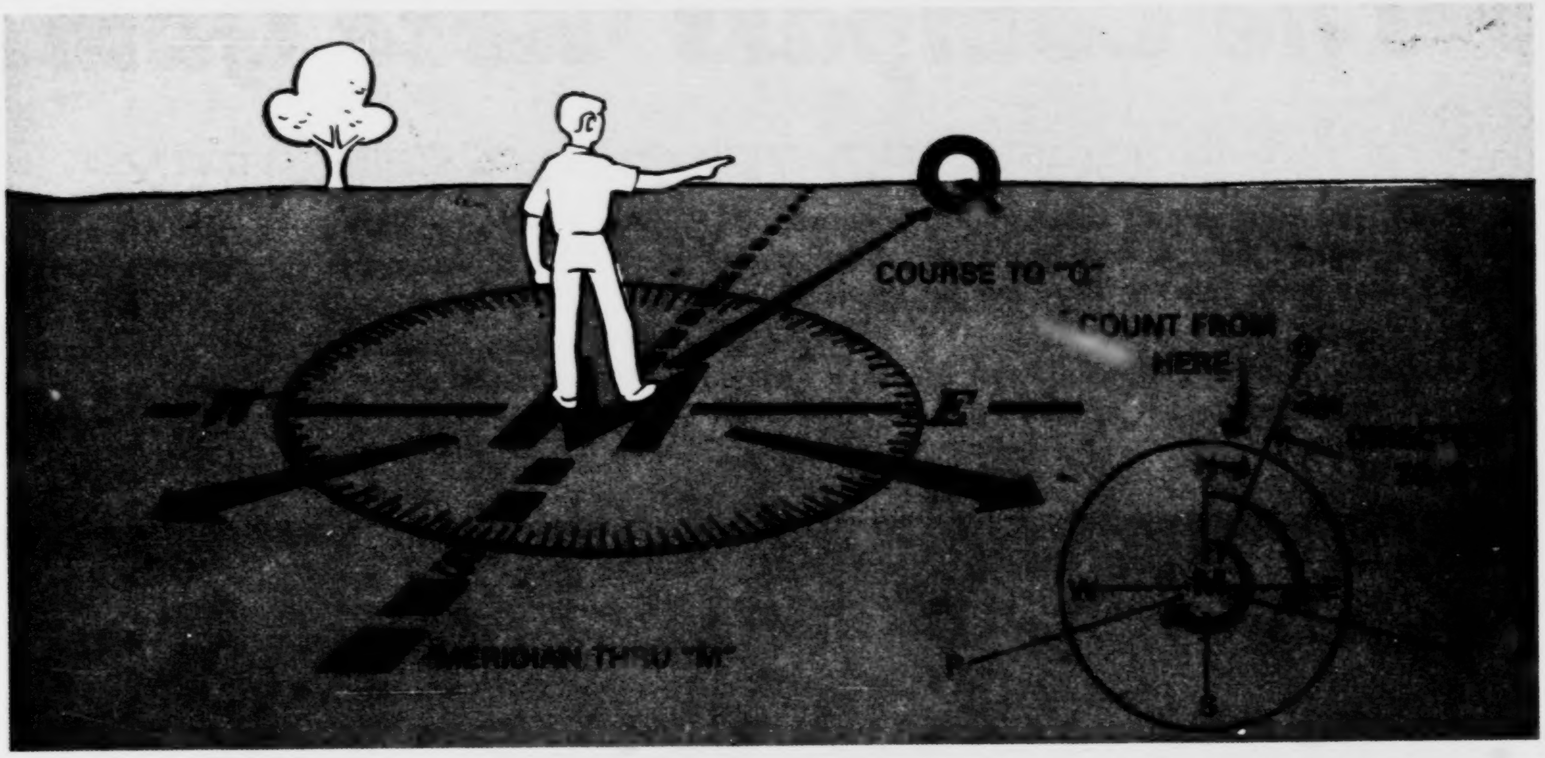
A SUGGESTED TEACHING STRATEGY

Basic to understanding maps and their application to finding one's way on the earth's surface is a thorough knowledge of the compass. From the ancient mariners to today's private pilots, the compass utilizing the magnetic north pole has been the primary instrument of navigation.

This "game" or activity is designed to help the children gain a basic understanding of cardinal directions in terms of the compass, and to refine that knowledge into understandings of the circle, angles, the great circle routes, and skills in identifying compass directions.


360
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
220
230
240
250
260
270
280
290
300
310
320
330
340
350
N
NE
E
SE
S
SW
W
NW

The Compass Rose



The direction from any given point on the earth's surface to any given point on the earth's surface is always measured as a certain number of degrees from north. One nautical mile is equal to one minute of arc at the equator and on all the lines of longitude. Sixty minutes of arc is equal to one degree.

The Game

Draw a large compass rose on a large piece of butcher paper, or draw with chalk directly on the floor. Have north, or 360°, correspond to actual north. Mark the center of the compass rose where a child will stand.

Divide the class into teams, and let each member of each team take turns standing in the compass rose. Members of the other team can call out compass headings from 001° (one degree) to 360° to the child standing in the center of the compass rose, who turns and faces the direction called for. He must turn to his **right** to be correct, since degrees are counted from north to east to south to west to north.

Variations on this activity can be made to be appropriate to several ability levels. For example, some children can face a given direction and be directed to turn **right** or **left** a given number of degrees. If he is facing 035° and is directed to turn left 020° , he will turn left and be facing 015° when he stops. Or he can face 280° and be directed to make a 180° right turn. When he stops he will be facing 100°

NOTE: In writing compass headings in numbers, one always writes three digits. If the compass heading is from one to nine, it is written 001° , 002° , 003° , etc. For headings over one hundred, no zero is placed before the number, as 180° , 283° , etc.

Orally, these directions, as they may be given to a pilot by a traffic controller on the radio, would be read "zero-zero-three degrees," or "zero-one-five degree", or "two-seven-zero degrees". Have the children use this terminology in performing the activity.

Reprinted by the Federal Aviation Administration
With permission from the Cessna Aircraft Company.

INTRODUCTION

The universe is governed by physical laws. On earth man has devised laws to govern his society. Some of these laws are based on morality or codes of ethics, others are designed to facilitate group living and are modified as society changes. The writing, observance, and enforcement of laws are basic to our American way of life.

Traffic laws came into being with widespread use of automobile transportation. Their purpose was to protect life, limb, and property. A driver must know and obey these laws if he is to retain his licensed right to drive.

As air transportation developed, laws were needed to govern it. The rapid increase in the number of aircraft has required traffic control in the air. Like the driver, the pilot must know and obey these laws if he is to retain his licensed right to fly.

Federal Aviation Regulations specify the requirements for pilots, air crew members, and other personnel. They set forth the standards for licensing, maintaining, and operating aircraft; they define minimum weather conditions for various types of flight; they provide controlled, restricted, and prohibited air spaces; they contain standards for certification of schools and instructors; and they provide for enforcement of the regulations by the Federal Aviation Administration under the Department of Transportation.

Pilots must know the law and obey it. Aviation is serious--deadly serious. An infraction of the law may result in loss of license--or loss of life. There is wisdom in the adage, "There are old pilots and there are bold pilots, but there are no old bold pilots."

TO THE TEACHER

The unit on Federal Aviation Regulations in the Aeronautical Science Course is intended to help the student to accomplish the following goals:

1. To understand the various kinds and sources of laws;
2. To learn respect for law established for the common good;
3. To differentiate between freedom and license;
4. To recognize the rights of others;
5. To comprehend that a good citizen strengthens democracy by his willing observance of the law;
6. To improve language skills and increase vocabulary through the mastery of Federal Aviation Regulations;
7. To become accustomed to the style that is used in phrasing law;

and, for the student who becomes a pilot, this unit is intended to help him

8. To understand, know, and want to comply with Federal Aviation Regulations;
9. To increase safety for himself and others by observance of these regulations;
10. To recognize the career opportunities as a civilian or military control tower operator, dispatcher, air traffic controller, or safety inspector.

A current set of Federal Aviation Regulations (FAR's) is necessary for the teaching of this unit. They may be purchased for a nominal fee from the Government Printing Office or from an aviation book store or a fixed base operator. There are many sources for FAR's but none is as accurate as the Federal Aviation Regulations themselves.

Other useful publications for this unit are:

*The Airman's Information Manual which may be obtained from the U. S. Government Printing Office, Washington, D. C. 20402. Accompany your order with check or money order payable to the Superintendent of Documents and allow several weeks for processing the order. Specify the following on your order:

Part 1. Basic Flight Manual and ATC Procedures - ($4.00 GPO)
Part 2. Airport Directory - $4.00
Part 3 and 3A. Operational Data and Notices to Airmen - ($20.00 GPO)

The National Transportation Safety Board Regulations -- Subchapter C: Safety Investigation Regulations Part 430. Order from the Government Printing Office, Price 5¢.

*See Page 80 for additional information on AIM's

Sanderson Films, AV Company, and Aero Products Research have good presentations of this material on record and film strip. Sanderson also has a good textbook and a programmed learning test on Federal Aviation Regulations. Supplement the lecture and classwork with tranparencies to provide complete understanding.

In order to be thoroughly qualified, it is recommended that the instructor be a licensed pilot. His license not only lends authority to his teaching, but in the process of preparing for the written and flight tests, he will have accumulated a thorough knowledge of the subject and, therefore,will be better prepared to teach.

Also, as soon as possible, the instructor should endeavor to obtain his Basic Ground School Certificate. This will pave the way for the school where he teaches to obtain the Air Agency, Pilot Ground School Certificate. All this lends a professional approach to what could otherwise be only a haphazard pursuit of the subject.

To qualify as a ground instructor a person must demonstrate his practical and theoretical knowledge of the subject by passing an FAA administered examination. See Part 143 of the Federal Aviation Regulations and obtain FAA Advisory Circular 143-1B, Ground Instructor Examination Guide - Basic - Advanced (4-18-67), ($1.00, GPO) for details and study material.

Reference material, Misenhimer - Rules of Flight Unit.

SPECIAL NOTICE

See Page 82 for information concerning the Federal Aviation Administration's conversion of the FAR's to a Volume format. At the time of final editing of this publication, several of the Volumes were available from the Superintendent of Documents, United States Government Printing Office, Washington, D. C. 20402.

Please consult the latest FAA Advisory Circular Checklist or the FAA Aviation News for the latest status of the FAR's, or write to the Superintendent of Documents for the latest information on the Volume availability.

UNIT OUTLINE

SUB-CHAPTER "A" DEFINITIONS

PART 1 Definitions and Abbreviations

SUB-CHAPTER "B" PROCEDURAL RULES

PART 11 General Rule-making Procedures
PART 13 Enforcement Procedures
PART 15 Nondiscrimination in Federally Assisted Programs of the Federal Aviation Administration

SUB-CHAPTER "C" AIRCRAFT

PART 21 Certification Procedures for Products and Parts
PART 23 Airworthiness Standards: Normal, Utility, and Acrobatic Category Airplanes
PART 25 Airworthiness Standards: Transport Category Airplanes
PART 27 Airworthiness Standards: Normal Category Rotorcraft
PART 29 Airworthiness Standards: Transport Category Rotorcraft
PART 31 Airworthiness Standards: Manned Free Balloons
PART 33 Airworthiness Standards: Aircraft Engines
PART 35 Airworthiness Standards: Propellers
PART 37 Technical Standard Order Authorizations
PART 39 Airworthiness Directives
PART 43 Maintenance, Preventive Maintenance, Rebuilding, and Alteration
PART 45 Identification and Registration Marking
PART 47 Aircraft Registration
PART 49 Recording of Aircraft Titles and Security Documents

SUB-CHAPTER "D" AIRMEN

PART 61 Certification: Pilots and Flight Instructors
PART 63 Certification: Flight Crewmembers Other Than Pilots
PART 65 Certification: Airmen Other Than Flight Crewmembers
PART 67 Medical Standards and Certification

SUB-CHAPTER "E" AIRSPACE

PART 71 Designation of Federal Airways, Controlled Airspace, and Reporting Points
PART 73 Special Use Airspace
PART 75 Establishment of Jet Routes
PART 77 Objects Affecting Navigable Airspace

SUB-CHAPTER "F" AIR TRAFFIC AND GENERAL OPERATING RULES

PART 91 General Operating and Flight Rules
PART 93 Specific Air Traffic Rules and Airport Traffic Patterns
PART 95 IFR Altitudes
PART 97 Standard Instrument Approach Procedures
PART 99 Security Control of Air Traffic
PART 101 Moored Balloons, Kites, Unmanned Rockets and Unmanned Free Balloons
PART 103 Transportation of Dangerous Articles and Magnetized Materials
PART 105 Parachute Jumping

FEDERAL AVIATION REGULATIONS

SUB-CHAPTER "G" AIR CARRIER AND COMMERCIAL OPERATOR CERTIFICATION AND OPERATIONS

- PART 121 Certification and Operations: Air Carriers and Commercial Operators of Large Aircraft
- PART 123 Certification and Operations: Air Travel Clubs Using Large Airplanes
- PART 127 Certification and Operations of Scheduled Air Carriers with Helicopters

SUB-CHAPTER "H" SCHOOLS AND OTHER CERTIFICATED AGENCIES

- PART 141 Pilot schools
- PART 143 Ground instructors
- PART 145 Repair stations
- PART 147 Mechanic schools
- PART 149 Parachute lofts

SUB-CHAPTER "I" AIRPORTS

- PART 151 Federal aid to Airports
- PART 153 Acquisition of U.S. land for Public Airports
- PART 155 Release of airport property from surplus property disposal restrictions
- PART 157 Notice of Construction, Alteration, Activation, and Deactivation of Airports
- PART 159 National Capital Airports

SUB-CHAPTER "J" ADMINISTRATIVE REGULATIONS

- PART 171 Non-Federal Navigation Facilities

I. FEDERAL AIR REGULATIONS

A. PART 61 CERTIFICATION: PILOTS AND FLIGHT INSTRUCTORS

1. SUB-PART "A" - GENERAL
    - 61.1 Applicability
    - 61.3 Certificates and ratings required
    - 61.5 Application and issue
    - 61.7 Temporary certificates
    - 61.9 Duration of certificates
    - 61.11 Exchange of certificates
    - 61.13 Change of name; replacement of lost or destroyed certificate
    - 61.15 Aircraft ratings
    - 61.16 General limitations
    - 61.17 Types of ratings and additional aircraft ratings (other than airline transport and lighter-than-air)
    - 61.19 Tests: general procedures
    - 61.20 Written tests: cheating or other unauthorized conduct
    - 61.21 Prerequisites for flight tests
    - 61.23 Flight tests: general procedures
    - 61.25 Flight tests: required aircraft

61.26 Flight tests: status of FAA inspectors and other authorized flight examiners
61.27 Retesting after failure
61.29 Graduates of certificated flying schools
61.31 Military pilots or former military pilots: special rules
61.33 Special-purpose pilot certificates other than airline transport: foreign citizens
61.35 Instrument rating: knowledge and experience requirements
61.37 Instrument rating: skill requirements
61.38 Glider towing: experience and instruction requirements
61.39 Pilot logbooks: except airline transport pilots
61.41 Pilot logbooks: airline transport pilots
61.43 Medical certificates: duration
61.45 Operations during physical deficiency
61.47 Recent flight experience
61.48 Applications, certificates, logbooks, reports and records: falsification, reproduction, or alteration
61.51 Change of address

2. SUB-PART "B" - STUDENT PILOTS
61.61 Eligibility requirements: general
61.63 Requirements for solo flight
61.65 Airplane operations: flight area limitations
61.67 Rotorcraft operations: flight area limitations
61.69 Glider operations: flight area limitations
61.71 Lighter-than-air operations: flight limitations
61.73 General limitations

3. SUB-PART "C" PRIVATE PILOT
61.81 Eligibility requirements: general
61.83 Aeronautical knowledge
61.85 Airplane rating: aeronautical experience
61.87 Airplane rating: aeronautical skill
61.89 Rotorcraft rating: aeronautical experience
61.91 Rotorcraft rating: aeronautical skill
61.93 Glider rating: aeronautical experience
61.95 Glider rating: aeronautical skill
61.97 Lighter-than-air rating (airship class): aeronautical experience
61.99 Lighter-than-air rating (airship class): aeronautical skill
61.101General privileges and limitations

B. PART 91 GENERAL OPERATING AND FLIGHT RULES
1. SUB-PART "A" - GENERAL
91.1 Applicability
91.3 Responsibility of the pilot
91.5 Pre-flight action
91.7 Flight crewmembers at stations
91.8 Prohibitions against interference with crewmembers
91.9 Careless or reckless operations
91.11 Liquor and drugs
91.13 Dropping objects
91.15 Parachutes and parachuting
91.17 Towing: gliders
91.18 Towing: other than under Part 91.17
91.19 Portable electronic devices

91.21 Flight instruction; simulated instrument flight and certain flight tests
91.23 Fuel requirements for flight in IFR conditions
91.25 VOR equipment check for IFR operations
91.27 Civil aircraft certificate requirements
91.29 Civil aircraft airworthiness
91.31 Civil aircraft operating limitations and markings requirement
91.33 Powered civil aircraft with standard category U.S. airworthiness certificates; instrument and equipment requirements
91.35 Flight recorders and cockpit voice recorders
91.37 Transport category: civil airplane weight limitations
91.38 Increased maximum certificated take-off weights for certain airplanes operated in Alaska
91.39 Restricted category civil aircraft: operating limitations
91.40 Limited category civil aircraft: operating limitations
91.41 Provisionally certificated civil aircraft: operating limitations
91.43 Special rules for foreign civil aircraft
91.45 Authorization for air carrier ferry flight of a four engine airplane with one engine inoperative
91.47 Emergency exits for airplanes carrying passengers for hire
91.49 Aural speed warning device

2. SUB-PART "B" - FLIGHT RULES

91.61 Applicability
91.63 Waivers
91.63 Operating near other aircraft
91.67 Right-of-way rules: except water operations
91.69 Right-of-way rules: water operations
91.71 Acrobatic flight
91.73 Aircraft lights
91.75 Compliance with ATC clearances and instructions
91.77 ATC light signals
91.79 Minimum safe altitudes: general
91.81 Altimeter settings
91.83 Flight plan: information required
91.85 Operating on or in the vicinity of an airport: general rules
91.87 Operation at airports with operating control towers
91.89 Operation at airports without control towers
91.91 Avoidance of disaster areas
91.93 Flight test areas
91.95 Restricted and prohibited areas
91.97 Positive control areas and route segments
91.99 Jet advisory areas
91.101 Operations to, or over, Cuba
91.103 Operation of civil aircraft of Cuban registry
91.104 Flight limitations in proximity of the Presidential party

VISUAL FLIGHT RULES: (VFR)
91.105 Basic VFR weather minimums (see enclosed sketch)
91.107 Special VFR weather minimums
91.109 VFR cruising altitude or flight level

3. SUB-PART "C" - MAINTENANCE, PREVENTIVE MAINTENANCE, AND ALTERATIONS
91.161 Applicability
91.163 General
91.165 Maintenance required
91.167 Carrying persons other than the crewmembers after repairs or alterations
91.169 Inspections
91.171 Progressive inspections
91.173 Maintenance records
91.175 Rebuilt engine maintenance records

C. PART 430 NATIONAL TRANSPORTATION SAFETY BOARD
1. SUB-PART "A" - GENERAL
    a. 430.1 Applicability
        1. Giving of notice and reporting of aircraft accidents
        2. Preservation of wreckage
        3. Investigation of the accident or overdue aircraft
    b. Definitions
        1. Accidents
        2. Injuries
        3. Damages, etc.
2. SUB-PART "B" - NOTIFICATION OF ACCIDENTS, INCIDENTS, AND OVERDUE AIRCRAFT
    a. 430.5 Immediate notification
    b. 430.6 Information to be given

3. SUB-PART "C" - PRESERVATION, ACCESS TO AND RELEASE OF AIRCRAFT WRECKAGE, MAIL, CARGE, AND RECORDS
    a. 430.10 Preservation of aircraft wreckage, mail, cargo, and records
    b. 430.11 Access to and release of aircraft wreckage, records, mail, and cargo

4. SUB-PART "D" - REPORTING OF AIRCRAFT ACCIDENTS, INCIDENTS, AND OVERDUE AIRCRAFT AND REPORTS AND STATEMENTS TO BE FILED

5. SUB-PART "E" - INVESTIGATION AND SPECIAL STUDIES
    a. 430.20 Authority of Board Representatives
    b. 430.25 Authority of the Director, Deputy Director, and hearing officers pertaining to aircraft accidents and air safety investigations

II. AIRMENS INFORMATION MANUAL

A. PART 1 BASIC FLIGHT MANUAL AND AIR TRAFFIC CONTROL PROCEDURE
1. Glossary
2. Good operating practice
3. Aeronautical information and the national airspace system
4. Aeronautical publications

FEDERAL AVIATION REGULATIONS

5. Air navigation radio aids
6. Airport air navigation lighting and markings
7. Altimetry
8. Medical facts for pilots
9. Radio telephone phraseology
10. Safety of flight
11. Weather
12. Landing aircraft (1-79)
13. Hand signals (1-81)

B. PART 2 AIRPORT DIRECTORY

C. PARTS 3 AND 3A OPERATIONAL DATA AND NOTICES TO AIRMEN

STATUS OF THE FEDERAL AVIATION REGULATIONS

As of July 1, 1969

The Federal Aviation Administration is re-issuing its Federal Aviation Regulations in a volume system. In about 12 months all FARs will be grouped into 11 volumes. As each volume is issued, an availability notice will be mailed to all persons now receiving the FARs. The availability of each new volume will also be reported in FAA Aviation News. In the meantime, the present publication system will remain in effect.

Distrbution of the volumes will be by the Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. 20402, who will set the price for each volume.

Volume I, which includes only FAR Part 1, became available in June.

FAR PART OR VOLUME NO.	TITLE	PRICE	CHANGES
Vol. I	(Part 1) Definitions and Abbreviations	$1.50 + 50c foreign mail	
11	General Rule-making Procedures	.35	9
13	Enforcement Procedures	.25	7
15	Nondiscrimination in Federally Assisted Programs of the Federal Aviation Administration	.20	....
21	Certification Procedures for Products and Parts	.60	21
23	Airworthiness Standards: Normal, Utility, and Acrobatic Category Airplanes	1.25	6
25	Airworthiness Standards: Transport Category Airplanes	2.25	19
27	Airworthiness Standards: Normal Category Rotorcraft	.70	3
29	Airworthiness Standards: Transport Category Rotorcraft	2.00	4
31	Airworthiness Standards: Manned Free Balloons	.20	2
33	Airworthiness Standards: Aircraft Engines	.40	3
35	Airworthiness Standards: Propellers	.30	2
37	Technical Standard Order Authorizations	1.00	5
**39	Airworthiness Directives	.20	1
43	Maintenance, Preventive Maintenance, Rebuilding, and Alteration	.55	9
45	Identification and Registration Marking	.30	6
47	Aircraft Registration	.25	6
49	Recording of Aircraft Titles and Security Documents	.20	4
61	Certification: Pilots and Flight Instructors	1.25	29
63	Certification: Flight Crewmembers Other Than Pilots	.35	10
65	Certification: Airmen Other Than Flight Crewmembers	.35	12
67	Medical Standards and Certification	.25	7
*71	Designation of Federal Airways, Controlled Airspace, and Reporting Points	.20	5
*73	Special Use Airspace	.20	1
*75	Establishment of Jet Routes	.20	2
77	Objects Affecting Navigable Airspace	.35	7
91	General Operating and Flight Rules	1.25	39
93	Specific Air Traffic Rules and Airport Traffic Patterns	.35	17
**95	IFR Altitudes	.25	....
**97	Standard Instrument Approach Procedures	.20	1
99	Security Control of Air Traffic	.25	7

NOTE: SEE NEXT PAGE FOR EXPLANATION OF THE NEW FAR ISSUANCE SYSTEM.

FAR PART OR VOLUME NO.	TITLE	PRICE	CHANGES
101	Moored Balloons, Kites, Unmanned Rockets and Unmanned Free Balloons	.20	2
103	Transportation of Dangerous Articles and Magnetized Materials	.20	5
105	Parachute Jumping	.20	4
121	Certification and Operations: Air Carriers and Commercial Operators of Large Aircraft	2.00	32
123	Certification and Operations: Air Travel Clubs Using Large Airplanes	.25	1
127	Certification and Operations of Scheduled Air Carriers with Helicopters	.35	10
129	Operations of Foreign Air Carriers	.20	4
133	Rotorcraft External-Load Operations	.20	3
135	Air Taxi Operators and Commercial Operators of Small Aircraft	.35	5
137	Agricultural Aircraft Operations	.25	3
141	Pilot Schools	.35	7
143	Ground Instructors	.25	3
145	Repair Stations	.40	8
147	Mechanic Schools	.20	1
149	Parachute Lofts	.25	1
151	Federal Aid to Airports	.40	28
153	Acquisition of U. S. Land for Public Airports	.20	4
155	Release of Airport Property from Surplus Property Disposal Restrictions	.20	....
157	Notice of Construction, Alteration, Activation, and Deactivation of Airports	.20	1
159	National Capital Airports	.30	11
161	(Deleted effective 6/1/66)		
163	(Deleted effective 7/1/65)		
165	Wake Island Code	.30	2
167	Annette Island, Alaska, Airport	.15	—
171	Non-Federal Navigation Facilities	.25	4
181	(Rescinded 4/1/67)		
183	Representatives of the Administrator	.20	Re-issued March 1968
185	Testimony by Employees and Production of Records in Legal Proceedings	.20	"
187	Fees	.20	"
189	Use of Federal Aviation Administration Communications System	.15	"

---

* Changes to individual airspace designations and airways descriptions, individual restricted areas, and individual jet route descriptions are not included in the basic Parts 71, 73 and 75 respectively because of their length and complexity. Such changes are published in the Federal Register and are included on appropriate aeronautical charts.

**Due to the complexity, length, and frequency of issuance, airworthiness directives, enroute IFR altitudes and instrument approach procedures are published in the Federal Register and therefore are not included in the basic Parts 39, 95 and 97. In addition, enroute IFR altitudes and instrument approach procedures are published in the Airman's Information Manual, and are depicted on aeronautical charts.

FEDERAL AVIATION REGULATIONS

New Issuance System for Federal Aviation Regulations -- The Federal Aviation Administration will begin to reissue its Federal Aviation Regulations in a volume system to be sold on a subscription basis by the Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. 20402. The first volume will appear in June 1969, and it will take approximately sixteen months to complete the transition from FAR Parts to volumes.

As each volume is issued, an availability notification providing price and an order form will be issued and distributed by the GPO. However, until all FAR parts are grouped in their respective volumes and the volumes are available for sale, the present system of obtaining individual FAR's and the revision service to them will remain in effect. The volume structure will be as follows:

VOLUME	FAR PART
I	1
II	11, 13, 15, 21, 37, 39, 45, 47, 49, 183, 185, 187, 189
III	23, 25
IV	27, 29, 31, 33, 35
V	43, 145, 149
VI	91, 93, 99, 101, 103, 105
VII	121, 123, 127, 129
VIII	133, 135, 137
IX	61, 63, 65, 67, 141, 143, 147
X	151, 153, 155, 159, 165, 167
XI	71, 73, 75, 77, 95, 97, 157, 169, 171

Date May 1, 1969

Pilots must know the Federal Aviation Regulations (FAR's) to operate an aircraft safely and to pass the examination given by the Federal Aviation Administration (FAA).

The FAA Private Pilot Written Examination includes questions based on the following FAR's and the National Transportation Safety Board's Safety Investigations, the most important of these being Parts 61 and 91.

In addition, Part 141, Pilot Schools, outlines the requirements necessary for the establishment of a certified ground school. All of these FAR parts should be on hand and kept updated.

Part 1 -- Definitions and Abreviations
Part 61 -- Certification of Pilots and Flight Instructors
Part 71 -- Designation of Federal Airways, Controlled Airspace, and Reporting Points
Part 75 -- Establishment of Jet Routes
Part 91 -- General Operating and Flight Rules
Part 95 -- IFR Altitudes
Part 97 -- Standard Instrument Approach Procedures
Part 99 -- Security Control of Air Traffic
Part 430 -- NTSB Rules Pertaining to Aircraft Accidents, Incidents, Overdue Aircraft, and Safety Investigations
Part 141 -- Pilot Schools, Sub-Part B, Ground Schools.

EXCERPT FROM

AIRMAN'S INFORMATION MANUAL

The Airman's Information Manual has been designed as a pilot's operational manual for use primarily within the conterminous United States. It is divided into three basic parts, each of which may be purchased separately.

New or amended textual or tabulated information except in the Airport/Facility Directory, is indicated by a solid dot ● prefixing the heading, paragraph, or line. Highlights of each part are described below.

PART 1

Basic Flight Manual and ATC Procedures

This part is issued quarterly and contains basic fundamentals required to fly in the National Airspace System; adverse factors affecting Safety of Flight; Health and Medical Facts of interest to pilots; ATC information affecting rules, regulations and procedures; a Glossary of Aeronautical Terms; U.S. Entry and Departure Procedures, including Airports of Entry and Landing Rights Airports; Air Defense Identification Zones (ADIZ); Designated Mountainous Areas; Scatana, and Emergency Procedures.

● Annual subscription price $4.00(Foreign mailing, $1.00 additional.)

PART 2

Airport Directory

This part is issued semiannually and contains a Directory of all Airports, Seaplanes Bases, and Heliports in the conterminous United States, Puerto Rico, and the Virgin Islands which are available for transient civil use. It includes all of their facilities and services, *except communications*, in codified form. Those airports with communications are also listed in Part 3 which reflects their radio facilities. A list of new and permanently closed airports which updates this part is contained in Part 3.

Included, also, is a list of selected Commercial Broadcast Stations of 100 watts or more of power.

● Annual subscription price $4.00. (Foreign mailing, $1.00 additional.)

PARTS 3 AND 3A

Operational Data and Notices to Airmen

Part 3 is issued every 28 days and contains a Master Alphabetical Index covering all Parts of the AIM; an Airport/Facility Directory containing a list of all major airports with communications; a tabulation of Air Navigation Radio Aids and their assigned frequencies; Parachute Jump Areas; Preferred Routes; Standard Instrument Departures (SIDs); Substitute Route Structures; a Sectional Chart Bulletin, which updates Sectional charts cumulatively; Restrictions to Enroute Navigation Aids; VOR Receiver Check Points; Special General and Area Notices; a tabulation of New and Permanently Closed Airports, which updates Part 2, and Oil Burner Routes.

Part 3A is issued every 14 days and contains Notices to Airmen considered essential to the safety of flight as well as supplemental data to Part 3.

● Annual subscription price $20.00 (Foreign mailing, $5.00 additional.)

These publications are available from the Superintendent of Documents, Government Printing Office, Washington, D.C. 20402. Orders should be accompanied by check or money order made payable to the Superintendent of Documents.

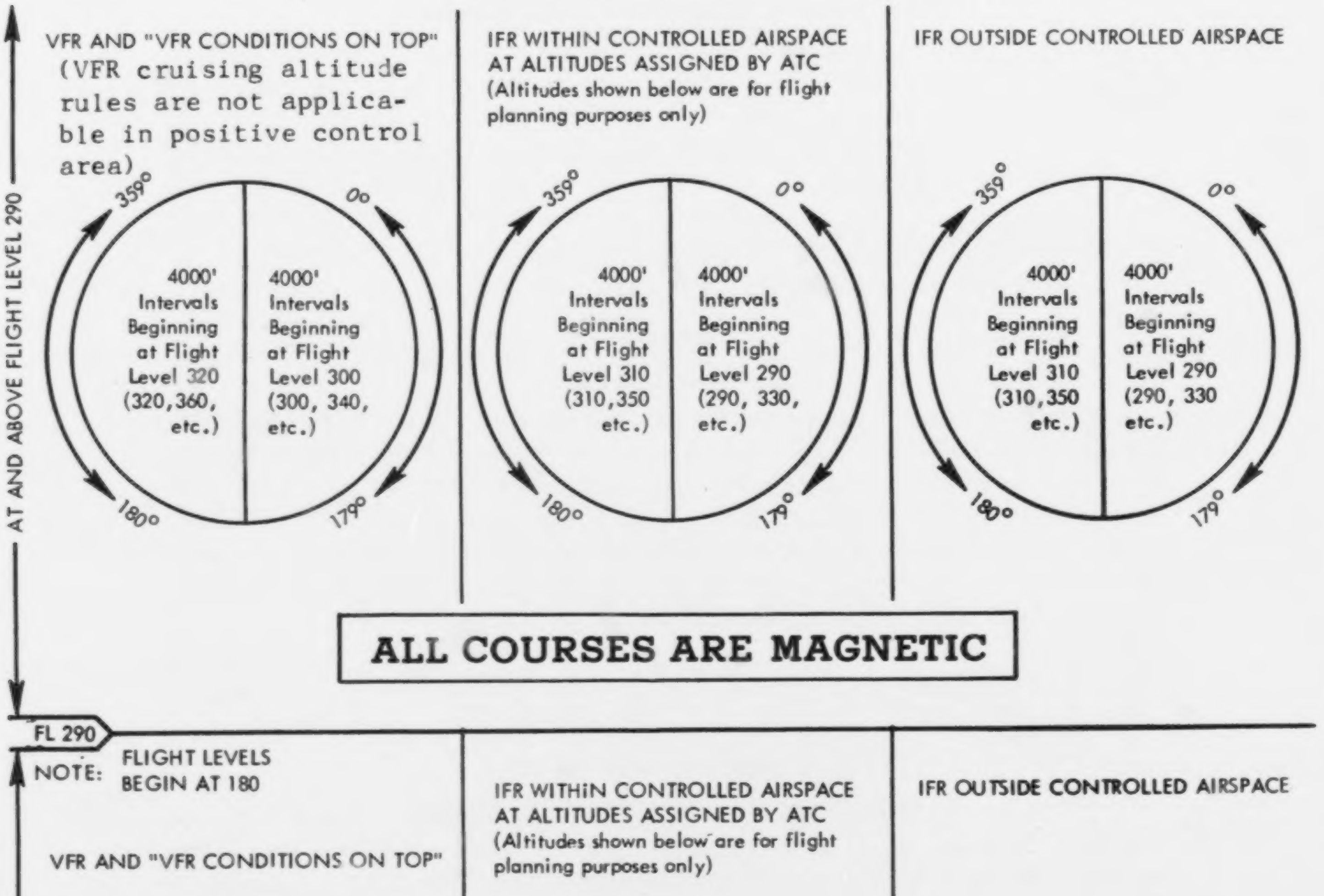
Errors, omissions or suggested changes should be forwarded to the Federal Aviation Administration, National Flight Data Center, AT–430, Washington, D. C. 20590.

EXCERPT FROM PART I AIM

ENROUTE

CRUISING ALTITUDES

FAR PARTS 91.109,91.121


AT AND ABOVE FLIGHT LEVEL 290
VFR AND "VFR CONDITIONS ON TOP"
(VFR cruising altitude rules are not applicable in positive control area)
359°
0°
4000' Intervals Beginning at Flight Level 320 (320,360, etc.)
4000' Intervals Beginning at Flight Level 300 (300, 340, etc.)
180°
179°
IFR WITHIN CONTROLLED AIRSPACE AT ALTITUDES ASSIGNED BY ATC
(Altitudes shown below are for flight planning purposes only)
359°
0°
4000' Intervals Beginning at Flight Level 310 (310,350 etc.)
4000' Intervals Beginning at Flight Level 290 (290, 330, etc.)
180°
179°
IFR OUTSIDE CONTROLLED AIRSPACE
359°
0°
4000' Intervals Beginning at Flight Level 310 (310,350 etc.)
4000' Intervals Beginning at Flight Level 290 (290, 330 etc.)
180°
179°
ALL COURSES ARE MAGNETIC
FL 290
NOTE: FLIGHT LEVELS BEGIN AT 180
BELOW FLIGHT LEVEL 290
VFR AND "VFR CONDITIONS ON TOP"
359°
0°
Even Thousands Plus 500' (4,500', 6,500', etc.--- and FL 185, 205,225 etc.
Odd Thousands Plus 500' (3,500', 5,500', -----or FL 195, 215,235
180°
179°
IFR WITHIN CONTROLLED AIRSPACE AT ALTITUDES ASSIGNED BY ATC
(Altitudes shown below are for flight planning purposes only)
359°
0°
Even Thousands (2,000', 4,000', etc---- and FL 180, 200, etc.
Odd Thousands (1,000', 3,000', etc. -----and FL 190 210, etc.
180°
179°
IFR OUTSIDE CONTROLLED AIRSPACE
359°
0°
Even Thousands (2,000', 4,000', -----or FL 180 200,220
Odd Thousands (1,000', 3,000', -----or FL 190 210,230
180°
179°
3,000 ABOVE THE SURFACE
VARIABLE FLOOR
SURFACE

EXCERPT FROM PART II AIM

AIRPORT DIRECTORY

UTAH—*Continued*

SOUTH HANKSVILLE See **HANKSVILLE**

SPANISH FORK, SPANISH FORK-SPRINGVILLE 2 NW
4529 H33/12-30 (2) (S-15) L4 S5 F12 **FSS: Salt Lake City**

STOCKS See **LA SAL**

TOOELE, MUNI 1 SW **FSS: Salt Lake City**
4983 H42 (1) (Max-10) F18

TREMONTON, MUNI 1 W **FSS: Malad City**
4332 H34 (1) (S-15) S3 F12, 18

UTAH CENTRAL See **SALT LAKE CITY**

§**VERNAL** 1 SE **FSS: Grand Junction**
5281 H66 (1) (S-45, T-60, TT-100) BL4 S5 F12, 18 U-1
Remarks: Rnwy 16 threshold displaced 618′.

VERNON, MUNI 1 NE **FSS: Salt Lake City**
5511 40 (1)
Remarks: Fence S.

WAYNE WONDERLAND See **LOA**

WENDOVER, BUSH-LELAND See **NEVADA**

WENDOVER, DOVER 4 SW **FSS: Salt Lake City**
4250 50 16-34 (1)
Remarks: Unattended.

WESTWATER 9 NW **FSS: Grand Junction**
4800 60 (2)

*** VERMONT ***

AUSTIN See **SWANTON**

§**BARRE-MONTPELIER,** BARRE MONTPELIER STATE IFR 3 W
FSS: Montpelier on Fld
1157 H45/17-35 (2) (S-55, T-80, TT-140) BL5 S5 F12, 18 U-2
VHF/DF: Ctc FSS
Remarks: P-line SW. Rnwy 5-23 ski equipped acft only winter months.

BASIN HARBOR See **VERGENNES**

BENNINGTON, BENNINGTON STATE 4 W **FSS: Albany**
821 H32/13-31 (1) L4[1] S3 F12, 18 U-1
VFR ADV: Ctc Albany App Con
Remarks: Attended 0800-2100 daily. [1]Opers thru unicom until 2100 lcl time, after by prior req-phone 447-7879.

BUNNELL AIRFIELD See **CANAAN**

§**BURLINGTON,** MUNI 2 E IFR AOE **FSS: Montpelier (LC 878-3393)**
335 H78 15-33 (2) (S-62, T-110, TT-195) BL5, 6, 8A, 9 S5
F12, 18, 22, 30, 40 U2 **RVV:** Rnwys 15 and 33.
Remarks: (£) For additional info see Part 3.

CANAAN, BUNNELL AIRFIELD 4 S **FSS: Montpelier**
1030 20 (1)
Remarks: Closed winters. Rgt tfc N.

CHAMPLAIN See **COLCHESTER**

VERMONT—*Continued*

COLCHESTER, CHAMPLAIN 6 W **FSS: Montpelier (LC 878-3393)**
125 19/2-20 (2) S3 F12, 18 U-1
Remarks: Attended 0800-dusk daily. P-line E.

ENOSBURG FALLS 2.7 NE **FSS: Montpelier**
410 30 (1) F12
Remarks: P-line NW. Fence W.

EQUINOX See **MANCHESTER**

FAIR HAVEN, MUNI 1 NW **FSS: Glens Falls**
370 23 (1)
Remarks: Closed winters.

HARTNESS MUNI See **SPRINGFIELD**

ISLAND POND STATE 3 SE **FSS: Montpelier**
1185 27 (1) U-1
Remarks: Attended daylight hours. Ski acft only winter months.

LONDONDERRY, NORTH WINDHAM 5 E **FSS: Lebanon**
1750 26/E-W (1) S3 F12, 18
Remarks: Attended dalgt hrs.

MANCHESTER, EQUINOX 1 SE **FSS: Glens Falls**
700 21 (2) S1 F12, 18
Remarks: Attended irregularly. Clsd winters.

MIDDLEBURY, MUNI 4 SE **FSS: Glens Falls**
490 H25/1-19 (1) (S-12.5) S5 F12, 18 U-1

MILLER See **WINDSOR**

§ **MORRISVILLE,** MORRISVILLE STOWE-STATE 2 S **FSS: Montpelier**
732 H27 (1) (S-30) BL5, 11 F18 U-1
REIL: Rnwy 1-19 on req.
Remarks: Fences S. Rnwy 1, rgt hand tfc, gliders only.

§**NEWPORT,** MUNI 3 S IFR **FSS: Montpelier**
930 H40 (2) (S-63, T-83, TT-126) *B L5[1] S5 F12, 18 U-1
Remarks: US Customs lndg rgts arpt. [1]Rnwy lgts on request after 2400, bcn on req only, both avbl by unicom or phone.

NORTH WINDHAM See **LONDONDERRY**

NORTH WINDHAM See **WINDHAM**

POST MILLS Adj E **FSS: Lebanon**
700 23 (1) S5 F12, 18 U-1
Remarks: P-line NE. Rgt tfc rnwy 5.

§**RUTLAND,** MUNI 5 SE IFR **FSS: Glens Falls**
787 H50 (2) (S-71, T-133, TT-230) BL5 S5 F12, 18, 30 U-1
Remarks: Use N/S rnwy when calm winds. Rgt tfc rnwy 19.

ST JOHNSBURY, MUNI 5 N **FSS: Montpelier**
814 23 (1) F12
Remarks: Unattended.

§ **SPRINGFIELD,** SPRINGFIELD STATE/HARTNESS 3 NW IFR
FSS: Lebanon
575 H40/11-29 (2) (S-31.5, T-55.5, TT-96) L5 S5 F12, 18 U-1

SWANTON, AUSTIN 1 NE **FSS: Montpelier**
248 21 (2) S5 F12
Remarks: Attended 0600-1800. US Customs lndg rgts arpt.

EXCERPT FROM PART III AIM

AIRPORT/FACILITY DIRECTORY

UTAH—*Continued*

PROVO (H) BVORTAC[2] 116.6/PVU/122.1R **FSS:** SALT LAKE CITY
NDB[1] **MHW** 222/PVU
Remarks: [1]Owned and operd by Utah State Aero Comm. [2]No wea bcst avbl from 2300-0500 lcl time.

SALT LAKE CITY FSS 121.5 122.0 122.1R 122.2 122.6

§SALT LAKE CITY INTL *IFR* 4W **FSS:** SALT LAKE CITY on Fld
4226 H100/16R-34L(2) (S-60, T-105, TT-175)
BL4,6,7,8A,9,10 S5 F12,15,18,22,30 U2 **VASI:** Rnwy 16R
RVR: Rnwy 34L
Remarks: *Rnwy 16L-34R (S-100, T-150, TT-300). Rnwy 14-32 restricted to acft in excess of 35,000 lbs.
Salt Lake Tower 118.3[2] 119.2[3] 122.7R **Gnd Con** 121.9
ATIS: 109.5
Radar Services: (BCN)
Salt Lake App Con 120.9 124.3 122.7R 116.8T
Salt Lake Dep Con 125.7
Tfc Info Ctc Salt Lake City App Con
ASR
ILS 109.5 I-SLC Apch Brg 339° **LOM:** 239/SL
(H) BVORTAC[1] 116.8/SLC 159° 2.9 NM to rnwy 16R and 149° 3.4 nmi to rnwy 16L.
VHF/DF Ctc FSS
Remarks: [1]No wea bcst avbl 2300-0500 lcl time. [2]34R, 16L. [3]16R, 34L. **VOT:** 111.0

VERNAL (L) BVOR 108.2/VEL/122.1R 123.6R **FSS:** GRAND JUNCTION

VERMONT

§ BURLINGTON INTL *IFR* 2E AOE **FSS:** MONTPELIER (LC 878-3393)
335 H78/15-33(2) (S-62, T-110, TT-195) BL5,6,8A,9 S5 F22,30 U2 **RVV:** Rnwy 15-33
Remarks: J-bar and A-gear rnwy 15-33.
Tower 118.3 122.5R 110.3T **Gnd Con** 121.9
Radar Services: (BCN)
App Con 121.1 122.5R 110.3T
Dep Con 119.2
Tfc Info Ctc App Con
ILS 110.3 I-BTV Apch Brg 146° BC unusable **LOM:** 219/BT
(L) BVOR 112.4/BTV/122.1R 122.3 122.6 123.6 033° 4.3NM to fld.
NDB SABH 323●/BTV 155° 1.8NM to fld.
VHF/DF Ctc twr
Remarks: **VOT:** 109.0.

HARTNESS NDB MHWZ 265/VSF **FSS:** LEBANON

MONTPELIER FSS 121.5 122.1R 122.3 122.6 123.6 **DF**

MONTPELIER (L) BVOR 108.2/MPV **FSS:** MONTPELIER on fld
NDB MHW 257/MPV

MORRISVILLE-STOWE NDB MHW 375/MVL **FSS:** MONTPELIER
Remarks: Owned & operd by Vermont Aeronautics Board.

NEWPORT NDB MHW 242/EFK **FSS:** MONTPELIER
Remarks: Owned & operd by Vermont Aeronautics Board.

RUTLAND NDB MHWZ 391/RUT **FSS:** GLENS FALLS
Remarks: Owned & operd by Vermont Aeronautics Board.

VIRGINIA

BLACKFORD (L) BVOR 110.2/BLA/122.1R **FSS:** BLUEFIELD

BLACKSTONE FSS 121.5 122.1R 122.6 123.6

BLACKSTONE NDB MHW 326/BKT
Remarks: Opers 0600-2200 lcl time, other hrs ctc Richmond FSS.

BROOKE (L) BVORTAC 111.8/BRV/122.1 **FSS:** WASHINGTON

VIRGINIA—*Continued*

CAPE CHARLES (L) BVORTAC 112.2/CCV/122.1R
FSS: NEWPORT NEWS

CASANOVA (H) BVORTAC .116.3/CSN/122.1R **FSS:** WASHINGTON

CHARLOTTESVILLE FSS 121.5 122.1R 122.3 122.6 123.6 **DF**

CHARLOTTESVILLE
§CHARLOTTESVILLE-ALBEMARLE *IFR* 7N
FSS: CHARLOTTESVILLE on fld
640 H60/3-21(1) BL6, 9, 11 S5 F18,45 U1 **REIL:** Rnwy 3
Remarks: Rnwy 21 threshold displaced 270′ SW.
ILS[1] 111.7 I-CHO Apch Brg 027° BC unusable
Charlottesville NDB MHW 229/AOM 027° 7.7NM to rnwy 03.
VHF/DF Ctc FSS
Remarks: [1]G/S not avbl.

CHASE CITY NDB MHW 342/CXE **FSS:** BLACKSTONE
Remarks: Operg on test UFN. Owned & operd by Virginia Div of Aeronautics.

DANVILLE FSS 121.5 122.1R 122.3 122.6 123.6

DANVILLE (L) BVOR 113.1/DAN **FSS:** DANVILLE

EMPORIA NDB MHW 346/EMV **FSS:** BLACKSTONE
Remarks: Owned & operd by Va Division of Aeronautics.

EVINGTON NDB MHW 385/EVI **FSS:** ROANOKE

FLAT ROCK (H) BVORTAC 113.3/FAK/122.19 **FSS:** RICHMOND

FRANKLIN (L) BVORTAC 110.6/FKN/122.1R **FSS:** NEWPORT NEWS

FRONT ROYAL (H) BVORTAC 115.3/FRR/122.1R **FSS:** MARTINSBURG

GORDONSVILLE (H) BVORTAC **FSS:** CHARLOTTESVILLE
115.6/GVE/121.5 122.3 122.6

HARCUM (L) BVOR 108.8/HCM/122.1R **FSS:** NEWPORT NEWS

HERNDON (L) BVORTAC 113.5/HRN/122.1R **FSS:** WASHINGTON

HOPEWELL (L) BVORTAC 112.0/HPW **FSS:** RICHMOND

HOT SPRINGS NDB MHWZ 224/HSP **FSS:** ROANOKE
Remarks: Owned by Va. Hot Springs Corp.

LAWRENCEVILLE (L) BVOR 112.9/LVL **FSS:** BLACKSTONE
Voice 0600-2200

LINDEN (L) BVORTAC 114.3/LDN **FSS:** WASHINGTON

§LYNCHBURG MUNI-PRESTON GLENN FLD *IFR* 6SW
FSS: ROANOKE (LC 846-3942)
942 H58/3-21(3) (S-60, T-80, TT-120) BL6,8A,9 S5 F18,30 U2 **RVV:** Rnwy 3.
Remarks: After 2400 rnwy lgts remain on 3-21 only. Apch lgts 0700-2400 lcl time.
Lynchburg Tower[2] 120.7 122.5R **Gnd Con** 121.9
Lynchburg App Con[2] 118.0 122.5R 120.7
ILS[1] 110.1 I-LYH Apch Brg 032°
Lynchburg (L) BVORTAC 109.2/LYH/122.1R 109.2T 025° 4.0NM to fld.
VHF/DF: Ctc twr
Remarks: [1]BC unusable below 3500′ MSL beyond 20 NM. [2]Opers 0700-2300 lcl time.

MELFA NDB MHW 388/MFV
Remarks: Owned & operd by Va Division of Aeronautics.

MONTEBELLO (L) BVOR 112.6/MOL/122.1R **FSS:** CHARLOTTESVILLE

MORRISON NDB MHW 248/MOV **FSS:** NEWPORT NEWS

NEWPORT NEWS FSS 121.5 122.1R 122.2 122.6

NEWPORT NEWS
§PATRICK HENRY *IFR* 9NW **FSS:** NEWPORT NEWS on Fld

EXAM-O-GRAMS

The Exam-o-grams are recommended for students who are earnestly seeking a pilot's license. The information below is self-explanatory:

12/68

VFR PILOT EXAM-O-GRAMS

Exam-O-Grams are brief and timely explanations of important aeronautical knowledge items. These items include concepts and procedures that are critical to aviation safety, common misconceptions among airman applicants, and areas which cause general difficulty in written tests.

Exam-O-Grams are developed on a continuing basis, only as needs arise, and not on a regularly scheduled basis. They are distributed free (one copy per request) to airman applicants, pilots, ground and flight instructors, educational institutions, airman training centers, flying clubs, and other interested groups and individuals. Exam-O-Grams may be reproduced without further permission from FAA.

VFR EXAM-O-GRAMS

Number	Title
2	VFR Cruising Altitudes
4	Preflight Planning for a VFR Cross-Country Flight (Series 1)
5	Preflight Planning for a VFR Cross-Country Flight (Series 2)
6	Preflight Planning for a VFR Cross-Country Flight (Series 3)
15	How to Use VOR (Series 1)
16	How to Use VOR (Series 2)
17	Common Misconceptions (Series 1)
18	Lost Procedures -- Pilotage
19	Emergency or Lost Procedures (Radio)
20	Ceiling and Visibility
21	Flying into Unfavorable Weather
22	Potential Mid-Air Collisions
23	Interpreting Sectional Charts (Ser. 1)
24	Interpreting Sectional Charts (Ser. 2)
25	Interpreting Sectional Charts (Ser. 3)
26	Common Misconceptions (Series 2)
27	The Effect of Wind on an Airplane
28	Factors Affecting Stall Speed
29	Potential Mid-Air Collisions (Series 2)
33	Use of Performance Charts
34	How to Obtain Proper Weather Briefing
35	UNICOM Frequencies and Uses
36	Commonly Misunderstood Areas of Aeronautical Knowledge (Series 1)
37	Commonly Misunderstood Areas of Aeronautical Knowledge (Series 2)
38	Mixture Control -- Fuel/Air Ratio
39	Simple ADF for VFR Navigation
41	Controlled Airspace (Series 1)
42	Controlled Airspace (Series 2)
43	ATIS (Automatic Terminal Information Service)
44	How High the Clouds?

In this set of Exam-O-Grams the following issues have been deleted: Nos. 1, 3, 7, 8, 9, 10, 11, 12, 13, 14, 30, 31, 32, and 40. They have been discontinued since the subject areas which they cover are now adequately treated in one or more of the following FAA publications:

Private Pilot's Handbook - AC 61-23
Aviation Weather - AC 00-6
Airman's Information Manual (annual subscription)
Other pertinent FAA Advisory Circulars

Purchase from: Superintendent of Documents
U. S. Government Printing Office
Washington, D. C. 20402

The Advisory Circular checklist and certain free Advisory Circulars may be obtained from:

Department of Transportation
Federal Aviation Administration
Distribution Unit, TAD-484.3
Washington, D. C. 20590

RESOURCES

FAA ADVISORY CIRCULARS

The instructor is advised to subscribe to the FAA Advisory Circulars, maintain a current file of them, and pass pertinent information on to his students. These circulars provide a systematic means for the issuance of nonregulatory material.

All advisory circulars are numbered to correspond with the sub-chapter, part, or, if appropriate, the specific section of the Federal Aviation Regulations. The general subject matter areas and related numbers are as follows:

Subject Number	Subject
00	General
10	Procedural
20	Aircraft
60	Airmen
70	Airspace
90	Air Traffic Control and General Operations
120	Air Carrier and Commercial Operations
140	Schools and Other Certified Agencies
150	Airports
170	Air Navigation Facilities
180	Administrative
210	Flight Information

Each circular will have a subject number followed by a dash and a sequential number. The same sequential number will not be used again with the same subject number. Revised circulars will have a letter A, B, C, etc., after the sequential number to show that the circular was completely revised.

Advisory circulars will be distributed routinely to persons on the FAA's mailing list for changes to the related Federal Aviation Regulations. Persons who want the free advisory circulars should write to the Department of Transportation, Federal Aviation Administration, Distribution Unit, TAD-484.3, Washington, D. C.20590. Be sure to identify the subject matter desired by the subject numbers and titles shown above, because separate mailing lists are maintained for each advisory circular subject series.

Some advisory circulars cannot be distributed free of charge. To obtain these make check or money order payable to "Superintendent of Documents" and mail to the U. S. Government Printing Office, Washington, D. C. 20402. Indicate the document number and title. Allow two to three months processing time at the Government Printing Office.

FEDERAL AVIATION REGULATIONS

Reference Books and Information:

Above and Beyond: The Encyclopedia of Aviation and Space Sciences. Chicago: New Horizons Publishers, Inc., 1968.

*Federal Aviation Administration, Advisory Circulars:

00-2	"Advisory Circular Checklist," (Latest Revision)
60-6	"FAA Approved Airplane Flight Manuals, Placards, Listings, Instrument Markings - Small Airplanes," (12-13-68).
61-34	*Federal Aviation Regulations Written Examination Guide*, (11-17-67). ($0.50 GPO).
70/7460-1	*Obstruction Marking and Lighting*, (2-29-68). ($0.60 GPO)
90-1A	"Civil Use of U. S. Government Produced Instrument Approach Charts," (4-10-68).
90-11A	"Air Traffic Control Radio Frequency Assignment Plan," (6-7-68).
143-1B	*Ground Instructor Examination Guide - Basic-Advanced*, (4-18-67). ($1.00 GPO).
150/5340-7A	"Marking and Lighting of Deceptive, Closed, and Hazardous Areas on Airports," (1-10-68).

Misenhimer, Ted G., Aeroscience, Culver City: Aero Products Research,Inc., 1969.

* See page 244 for information as to how to obtain.

Other Aids:

*Aero Products Research, Private Pilot Course, FAR Section.
AVCO, Private Pilot Course, FAR Section.
*Jeppesen & Company, Private Pilot Course, FAR Section.
*Sanderson Films, Inc., Federal Aviation Regulations, Private Pilot.

*See page 254 for addresses

INTRODUCTION

Man's conquest of the air has led him into increasingly greater speeds. At one time the rate of a mile per minute was thought to be man's limit because he could not catch his breath at speeds greater than 60 miles per hour!

The piston engine reaches its limit at nearly 500 miles per hour, but the reaction engines have opened up new horizons in speed. Within the earth's atmosphere, man's speed limit is governed by the effectiveness of the refrigeration unit he carries, the melting point of his metal airplane, and his earthbound brothers' tolerance to sonic boom. But outside the atmosphere, the limit is bounded by the speed of light and the gravitational effect of the heavenly bodies.

Speeds will continue to increase both within and without the earth's atmosphere. How fast man will eventually be able to travel depends upon his research and development in metals, ceramics, aerodynamics and propulsion. The next decade will see supersonic speeds well established as we scoot around the world in our supersonic transports.

TO THE TEACHER

This study outline is based upon the Shell Oil Company film series relating to the three areas of sonic flight; namely, "Approaching the Speed of Sound," "Transonic Flight," and "Beyond the Speed of Sound." Therefore, the teacher should make every attempt to thoroughly acquaint himself with these films.

All three textbooks listed in the resources have chapters related to the speed of sound. However, it would be advisable to review a good physics textbook in order to refresh one's memory regarding the fundamentals of the characteristics of sound.

The purpose in including this unit is to create an awareness of the student and to energize his curiosity and thinking about this most timely aspect of flight. After all, we must be able to live comfortably with supersonic speeds -- it is here to stay with all its aerodynamic, social, economical, and physiological problems.

UNIT OUTLINE

I. Definition of the speed of sound
  - A. Wave motion
  - B. Properties of sound
  - C. Speed - in air at 59°F
    - 1. Influence of altitude change

Van Deventer, 108
Van Sickle, 67
Tower, 48
"Sonic Boom" - North American Rockwell Corporation

II. Substances through which sound travels
  - A. Air
  - B. Steel
  - C. Water
  - D. Vacuum

Joseph, *A Source Book for the Physical Sciences*, pp. 426-431 for demonstrations

Van Deventer, 110 (Table)

III. Transverse and longitudinal waves
  - A. Crest
  - B. Trough
  - C. Amplitude
  - D. Frequency
  - E. Compression
  - F. Rarefaction

Shell Oil Co. films: "Approaching the Speed of Sound"
"Through the Speed of Sound"
"Beyond the Speed of Sound"

IV. How sound is produced - vibrating objects

Van Deventer, 109
Use tuning fork

V. Source of pressure waves

Describe Doppler effect

VI. Mach Number - definition
  - A. Speed ranges
    - 1. Subsonic - below M 0.85
    - 2. Transonic - M 0.85 to M 1.2
    - 3. Supersonic - M 1.2 to M 5.0
    - 4. Hypersonic - above M 5.0

$$M = \frac{v}{a}$$

M = Mach no.
v = True Air Speed
a = Speed of Sound

VII. Transonic flight
  - A. Formation of shock waves
  - B. Critical Mach Number (M crit.)
  - C. Bow wave
  - D. Mach cone and angle
  - E. Sonic boom
  - F. Shock induced separation
  - G. Raising M crit.
    - 1. Wing thickness
    - 2. Sweepback
    - 3. Tip stalling
    - 4. Spanwise flow
    - 5. Taper effect on tip stalling

Van Deventer, 113, Fig. 6

FILMS: "Sonic Boom and You" and "Ticket through the Sound Barrier."

Misenhimer - High Speed Aerodynamics Unit

- H. Overcoming tip stall
  - 1. "Washout" wing tips
  - 2. Vary section camber
  - 3. Flow fences
  - 4. Slats
- I. Mixed flow M crit to M 1.3

VIII. Supersonic

- A. Airfoil characteristics
  - 1. Expansion wave
  - 2. Double wedge — Van Deventer, 122
  - 3. Double arc
- B. Swept wing versus straight wing
- C. Controls
  - 1. Slab stabalizer
  - 2. "T" Tails
  - 3. Control assists
  - 4. Servo tabs
  - 5. Vortex generators
- D. Heat barrier
  - 1. Temperatures
  - 2. Metals, ceramics, paints — Van Deventer, 127
  - 3. Cooling problems -- sealants
    - a. Tires — FILM: "SST Film Report"
    - b. Fuel
    - c. Payload

95/96

RESOURCES

Textbooks:

Tower, Merrill, Basic Aeronautics. Fallbrook, California: Aero Publishers, 1955.
Van Deventer, An Introduction to General Aeronautics. American Technical Society, 1965.
Van Sickle, Neil D., Modern Airmanship, 3rd Edition. Princeton, New Jersey: Van Nostrand, 1966.

Reference Books and Other Information:

Above and Beyond: The Encyclopedia of Aviation and Space Sciences. Chicago: New Horizons Publishers, Inc., 1968.
Bisplinghoff, R. L., "The Supersonic Transport," Scientific American, June 1964.
Boeing Company, Sonic Boom. Boeing Document D 6 A 10598-1, 1967.
Duke, Neville, Sound Barrier: The Story of High-speed Flight.Philosophic Library, New York, 1965.
Field, Roland L., Measurement of Sound Levels Associated with Aircraft, Highway, and Railroad Traffic. U. S. Dept. of Commerce, Washington, D.C. 1947.
Freeman, Jacob J., Principles of Noise. Wiley, New York, 1958.
Hastings, Russell B., The Physics of Sound. Bruce Pub., St. Paul, 1960.
Joseph, Alexander, Paul F. Branawein, Evelyn Morholt, Harvey Pollack and Joseph F. Castka, A Sourcebook for the Physical Sciences. New York: Harcourt, Brace & World, Inc., 1961.
Kinsler, Lawrence B., Fundamentals of Acoustics, Wiley, New York, 1962.
Peterson, Arnold P., Handbook of Noise Measurement. General Radio Co., West Concord, Massachusetts, 1967.
Rice, Raymond H., "Sonic Boom, " North American Rockwell Corporation, Los Angeles, California 90045
Roberts, Joseph B., The Sound of Wings; Readings for the Air Age. Holt, New York, 1957.

Films:

*Douglas Aircraft Company, "SST Film Report," 1964, 22 Min. This film is highly technical. It shows the testing and assembly techniques employed in the experimental phase of developing metal structures suitable for use in the proposed Supersonic Transport (SST).
*Federal Aviation Administration,"Sonic Boom and You," (FA-811). 1968, Color, 10 Min.
*National Aeronautics and Space Administration, "Ticket Through the Sound Barrier," (HQk-SR 10). 1966, 28 Min.
*Shell Oil Company: "Approaching the Speed of Sound," "Transonic Flight," "Beyond the Speed of Sound."

* See pages 233 and 234 for addresses.

Other Aids:

Boeing Aircraft Co., Supersonic Transport Branch, Public Relations, Box 3733, Seattle, Washington, 98124. Information on current development of the Supersonic Transport Aircraft.

General Electric Co. Aircraft Engine Group, Cincinnati, Ohio, 45215. Information on current development of the GE4 turbojet engine for the Supersonic Transport.

INTRODUCTION

Man readily adjusts to his surroundings if the extremes aren't too great. The human body is capable of constant adjustments to changes in temperature, physical activity, motion through space, acceleration and deceleration forces, and so forth. However, the capability of the body to make these adjustments and to maintain the internal environment of the body within very narrow limits is limited. In other words, man can stand only so much and no more!

In aviation, the demands upon the compensatory mechanisms of the body are numerous and of considerable magnitude. Those demands of greatest significance are changes in:

1. Pressure
2. Temperature
3. Velocity within the three dimensions.

Recently, aircraft have been developed that are capable of taxing man's tolerances to the utmost. These aircraft cannot be operated at their full capacity without mechanical aids that will enable pilot and crew to function properly and without physical incapacitation.

It behooves pilots to understand the mechanical characteristics of their machines and to know the functions of the human body under the special conditions imposed by flight, and just as important, he must understand the mechanical aids that enable him to survive and function within a hostile environment.

Since man is the major limiting factor in certain aspects of flight, it again behooves him to overcome all indifference, ignorance, and carelessness in order that all the foresight, ingenuity, and effort that have gone into all aspects of flight planning not be nullified.

TO THE TEACHER

The unit on Physiology of Flight in the Aeronautical Science course has significance for all students and special meaning to the pre-medical student. Also, those considering nursing or research biology careers will find the information helpful. It is intended to help the student to accomplish the following goals:

1. To understand the basic needs of the human body.
2. To appreciate the effects on the body of oxygen, temperature, and pressure.
3. To comprehend precautions to be observed for safe and comfortable flight travel.
4. To recognize physical limitations of the body in flight.
5. To realize the need that exists to overcome these limitations.

References throughout the course outline are to sources listed at the back of the unit on the page entitled "Resources."

Team-teaching with a physiology teacher is suggested for this unit. The school doctor or a local physician offers a resource possibility for a guest lecturer. An FAA designated aviation medical examiner may be especially helpful.

UNIT OUTLINE

I. Physics of the Atmosphere

Physiological Training, pp. 2 - 5
Sanderson Films, Inc.: Oxygen, Altitude and the Body

- A. Composition of the Atmosphere
  - 1. Nitrogen 78%
  - 2. Oxygen 21%
  - 3. Other Gases 1%
    (Argon, Carbon Dioxide
    Neon, Helium, Hydrogen)
  - 4. Percentages at Altitude

Misenhimer - Physiology of Flight Unit

- B. Methods of Expressing Altitude
  - 1. Gravitational Pull
  - 2. Standard Atmospheric Conditions 29.92" HG at Sea Level 14.7 lbs PSI at 15°C
  - 3. Decrease of pressure and temperature with altitude 1" mercury per thousand feet
    3½° F per thousand feet
- C. Divisions of the Atmosphere
  - 1. Physiological Zone
    - a. Sea Level - 12,000 ft.
    - b. Minor physiological disturbances experienced
  - 2. Physiological Deficient Zone
    - a. 12,000 ft. - 50,000 ft.
    - b. Oxygen deficiencies
    - c. Trapped and evolved gases become major problems
  - 3. The Partially Space Equivalent Zone
    - a. 50,000 ft - 120 miles
    - b. Pressure change only 1 PSI
    - c. Blood boils at 63,000 ft. without pressurization
  - 4. The Totally Space Equivalent Zone
    - a. 120 miles and beyond
    - b. True Space

II. Physical Gas Laws

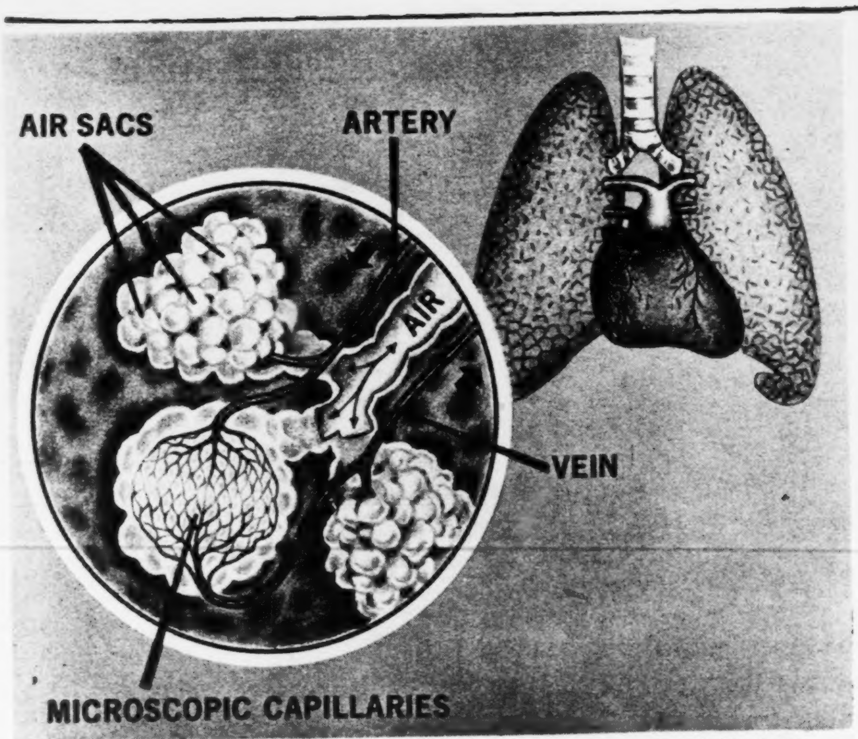
- A. Boyle's Law: The volume of a gas is inversely proportional to its pressure, temperature remaining constant.
- B. Dalton's Law: The total pressure of a mixture of gases is equal to the sum of the partial pressures of each gas in that mixture.
- C. Henry's Law: The amount of gas in solution varies directly with the partial pressure of that gas over the solution.
- D. Charles' Law: If the volume of a gas remains constant, the pressure will vary directly with its temperature.

III. Respiration and Circulation — *Physiological Training*, pp. 5 - 8

- A. Definition of Respiration
  - 1. Absorption of Oxygen
  - 2. Elimination of CO_2
- B. Process of Respiration
  - 1. Inspiration and expiration
    - a. Muscular Action
    - b. Diaphragm
  - 2. Nasal Passages
  - 3. Windpipe and Bronchial Tubes
  - 4. Lungs
    - a. Alveoli
    - b. Capillaries
    - c. Exchange of gases
- C. Circulation
  - 1. Function
  - 2. Structure
    - a. Heart
    - b. Arteries
    - c. Veins
    - d. Capillaries
- D. CO_2 and Heart Rate
- E. Composition of the Blood
  - 1. Plasma
  - 2. Solids
  - 3. White Blood Cells
  - 4. Red Blood Cells
  - 5. Hemoglobin
    - a. Importance in transmission of oxygen

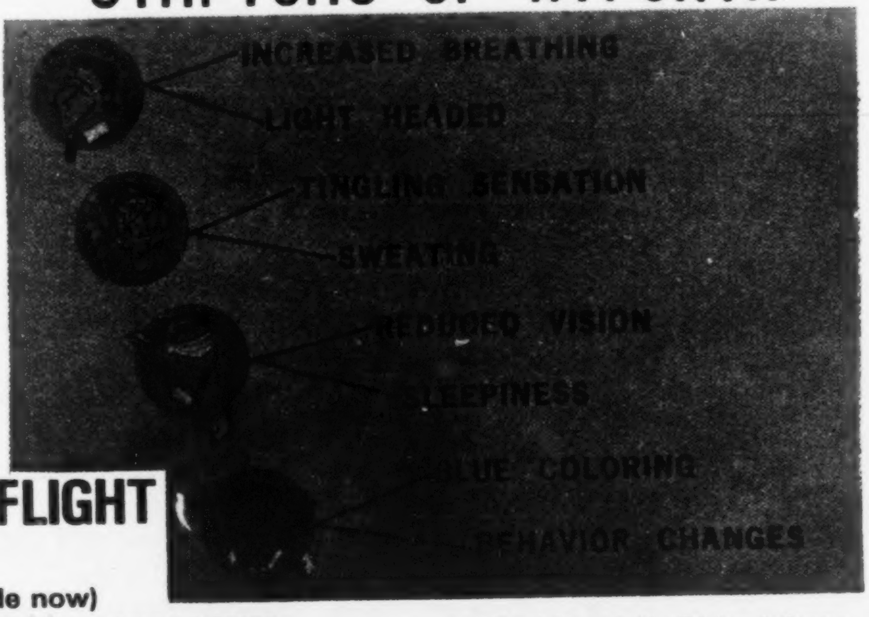
IV. Hypoxia — Van Sickle, pp.235-246

- A. Causes — *Physiological Training*, pp. 8-10.
  - 1. Reduction of Partial Pressure
- B. Symptoms
  - 1. Breathing Rate
  - 2. Dizziness
  - 3. Tingling
  - 4. Sweating
  - 5. Vision Deficiencies
  - 6. Coloring
  - 7. Abnormal Behavior
- C. Time of Useful Consciousness
  - 1. At altitudes without supplemental oxygen
  - 2. Factors
- D. Overcoming Hypoxia


AIR SACS
ARTERY
AIR
VEIN
MICROSCOPIC CAPILLARIES

The transfer of oxygen through the blood is thoroughly explained by a series of authentic medical illustrations.

SYMPTOMS OF HYPOXIA


INCREASED BREATHING
LIGHT HEADED
TINGLING SENSATION
SWEATING
REDUCED VISION
SLEEPINESS
BLUE COLORING
BEHAVIOR CHANGES

Hypoxia is a result of insufficient supply of oxygen.

MEDICAL FACTORS OF FLIGHT

SECTION I

Oxygen, Altitude and the Body (Available now)

A discussion of the composition of the air and how oxygen transfers from the air sac to the bloodstream providing an understanding of why hypoxia occurs. Hyperventilation and its effects are also covered.

SECTION II

Oxygen Systems

The development of oxygen systems in use today as well as how to use them.

SECTION III

Effects of Drugs and Alcohol
(In production for future release)

The effects of drugs and alcohol on body functions presented as general information and in specific relationship to flying.

SECTION IV

Effect on Vision (In production for future release)

The eye and its function as it relates to the pilot and flight, including depth perception, night vision, peripheral vision and relative motion.

Sanderson
FILMS, INC. AVIATION VISUAL AIDS

V. Hyperventilation

Physiology Training, pp. 10 - 11.

- A. Definition and Causes
- B. Symptoms
- C. Combined with Hypoxia
- D. Treatment

VI. Decompression Sickness (Dysbarisms)

Van Sickle, pp. 251-254
Physiological Training, pp. 11 - 15

- A. Definition
- B. Parts of Body Affected
  - 1. Ear
  - 2. Sinus
  - 3. Abdomen
    - a. Foods
    - b. Gastrointestinal gas expands with altitude, bringing discomfort. It is formed by swallowing air and by digestive process and is formed by foods such as beans, cabbage, fresh bread, etc.
  - 4. Teeth

Show film: "R_X for Flight"
Van Deventer, pp. 243-245

- C. Causes and Effects
  - 1. Formation of gas (Nitrogen) bubbles cause pain
  - 2. Nitrogen bubbles obstruct small blood vessels and create pressure on small nerves
  - 3. Pain is sudden and worsens if altitude is maintained:
    - a. Bends - pain in joints
    - b. Chokes - chest pain, shortness of breath, coughing
    - c. Skin burns, itches, becomes warm, cold, and mottled - rash
    - d. Partial loss of vision and speech and partial paralysis
    - e. Common, but rarely fatal, depending upon degree

Van Sickle, pp. 246-250

- D. Decompression sickness occurs in direct ratio with:
  - 1. Pressure altitude
  - 2. Rate of climb
  - 3. Total time spent at altitude
  - 4. Amount of exercise performed
  - 5. Age of subject
  - 6. Fatness of subject
- E. Cure and Prevention
  - 1. Only cure is immediate recompression (descent)
  - 2. Prevention is afforded by breathing 100% oxygen an hour prior to take-off
  - 3. Pressurized cabin is another prevention

VI. Decompression Sickness (Dysbarisms) Continued:

- F. Evolved Gases
- G. Nitrogen and Henry's Law
- H. Paresthesia
- I. Visual Disturbances
- J. Shock
- K. Treatment

VII. Pressurization

Physiological Training, pp. 15 - 17

- A. Methods
- B. High Altitude Emergencies
  - 1. Sudden decompression due to:
    - a. Failure of pressurizing system
    - b. Break in cabin wall
  - 2. Dangers include:
    - a. Being swept from plane by blast of air
    - b. Pain, but not injury, in the intestinal tract
    - c. Decompression sickness
    - d. Hypoxia
  - 3. Prevention includes:
    - a. Use of seat belts
    - b. Readiness of oxygen masks
    - c. Above 43,000 ft., use of pressurized helmet, and automatic oxygen assembly.

Van Sickle, pp 256-259

VIII. Vision in Flight

Van Sickle, pp. 259-265

- A. Structure of the eye:
  - 1. Cornea
  - 2. Iris
  - 3. Pupil
  - 4. Lens
  - 5. Retina:
    - a. Cones; central vision, color, daylight or illumination
    - b. Rods: Peripheral vision and night vision
  - 6. Optic nerve

Van Deventer, pp. 241-243
Physiological Training, pp. 17 - 19
Explore possibilities of team-teaching with the physiology teacher or invite a doctor as a resource person.

Check physics laboratory manual for experiments on light and images.
Borrow diagram of eye from physiology laboratory.
"Just a See Story"- Approach - The Naval Aviation Safety Review Magazine.

- B. Visual Acuity
  - 1. Meaning of 20/20
  - 2. Diminishes toward periphery of retina
  - 3. Diminishes if eye is in motion
  - 4. Eye fatigue from ultraviolet and infrared light

Snellen Test of Visual Acuity

Sanderson Films, Inc.: Effect on Vision (In production July 1969)

VIII. Vision in Flight (Continued)

C. Depth Perception

D. Night Vision
1. Adaptation to dark (Vitamin A required)
2. Eccentric vision (10° off-center)
3. Easily affected by hypoxia
4. Limited by smoking or by absorption of carbon monoxide
5. Visual Illusions
a. Autokinetic or "stare" vision
b. Causes unknown
c. Cure: Shift gaze often

Experiment in darkened room to determine the difference between central and peripheral vision.

E. Color Vision
1. Hereditary blindness (or deficiency)
2. 10% of males; 2% of females
3. Red/green most often confused
4. Defect increases with excitement or nervousness

The Ishihara test (colored dots) will let students evaluate their own degree of color vision.

F. High-speed Vision
1. Faster aircraft require:
a. Quicker recognition
b. Faster reaction time
2. Reaction time increased by mental dullness, fatigue, or inattention

IX. Other Physiological Effects

A. Physiology of the Ear

Use ear chart from Physiology Lab.

B. Noise in Flight
1. Measure
a. Pitch
(1) Cycles per second (cps)
(2) Human range 500-5000 cps
b. Intensity
(1) Decibles (db)
(2) Audible range 10-140 db
2. Sources
a. Propeller-driven aircraft
(1) Propeller
(2) Engine
(3) Exhaust
(4) Ventilating system
(5) Aerodynamic noises

Van Deventer, pp. 243-248
Van Sickle, pp. 281-285

Physics experiments on sound

IX. B. 2. Other Physiological Effects Continued:

b. Jet aircraft
(1) Aerodynamic noises
(2) Origin of most noise is outside aircraft
c. Radio static
3. Effects
a. Temporary hearing loss
b. Fatigue due to noise
4. Prevention
a. Ear plugs
b. Helmets padded with sponge rubber

C. Vibration
1. Effects on vision

D. Temperature extremes
1. Tolerances
2. Source
3. Extent and Dangers

Physiological Training, pp. 20 - 21

E. Effects of Speed
1. Time Lag
a. Perception
b. Brain
c. Reaction

Physiological Training, pp. 21

X. Sensory Illusions During Flight

Physiological Training, pp. 22 - 26.

A. Equilibrium Organs
1. Eyes
2. Inner Ear
3. Skeletal Muscles

B. Vertigo

C. Overcoming Illusions
1. Time Lag
2. Mechanical Substitutes - IFR
a. Instruments
3. Frequencies of Illusions

XI. Other Medical Factors

A. General Health
1. Conditions leading to sudden incapacitation
2. Temporary incapacitation

XI. Other Medical Factors - Continued

- B. Fatigue

- C. Alcohol
    1. Metabolic Rate
    2. Effect

Show film "Charlie"

- D. Drugs
    1. Self-medication
        - a. Aspirin
        - b. Antihistamines
        - c. Reducing Drugs
        - d. Laxatives
        - e. Cough Mixtures
        - f. Tranquilizers
        - g. Barbiturates

Medical Facts for Pilots
Mohler & Siegel - FAA

- E. Vertigo
- F. Flicker Vertigo
- G. Carbon Monoxide
    1. Characteristics
    2. Oxygen and carbon monoxide
    3. Source
    4. Recovery from effects

- H. Smoking and Vision
- I. Head Colds
- J. Scuba Diving

XII. Acceleration

Van Sickle, pp. 265-274

- A. Definitions
    1. Speed is rate of motion
    2. Velocity is speed and direction
    3. Acceleration is increase in velocity
    4. Deceleration is decrease in velocity

- B. Measurement: Unit of "g"

Check Physics Lab manual for experiments on acceleration

- C. Means of acceleration
    1. Linear
    2. Radial
    3. Angular

- D. Direction of acceleration
    1. Vertical
        - a. Positive
        - b. Negative
    2. Sagittal
    3. Transverse

XII. Acceleration - Continued

- E. Duration of acceleration
  - 1. Prolonged (more than 1 sec.)
  - 2. Sudden (less than 1 sec.)
- F. Man's Acceleration Tolerance
  - 1. Dependent on means, direction and duration
  - 2. Varies from 46.8g sagittal for .008 sec. (sudden) to 3g vertical for 5 seconds (prolonged)

Show film, "The Universe Within"

- G. Effects
  - 1. Loss of vision
  - 2. Unconsciousness
  - 3. Face sags
  - 4. Limbs heavy
  - 5. Movements restricted
  - 6. Blood vessels and heart, pressure
- H. Compensations
  - 1. Crouching position
  - 2. Prone position
  - 3. Anti-g suits; such suits are no protection against negative g

XIII. Medical Aspects of Space Flight

- A. Respiratory Problems
- B. Acceleration Forces
- C. Weightlessness
- D. Radiation Hazards
- E. Space Flight and Nutrition
- F. Bodily Wastes
- G. Meteoroids
- H. Psychological Problems

Film: "Space Medicine" *Space Medicine in Project Mercury*

The Measurement of Blood Pressure in the Human Body

Film: "Food for Space Travelers" *Space Cabin Atmospheres -Part I: Ozygen Toxicity*

Also see unit outline on MAN IN SPACE

EXPERIMENT I - Structure of the Respiratory System

Plants and animals are aerobes which means that their cells require oxygen for the liberation of energy, and since carbon dioxide is a by-product of energy liberation, it must be eliminated from the organism.

Purpose: To study the different organs or parts which constitute the respiratory system.

Materials:
1. Sheep lungs with trachea and part of diaphragm
2. Dissecting pans
3. Scalpel, scissors, glass tubes
4. Dish of water, microscope, prepared slides of lung tissue

Procedure:
1. Place lungs in dissecting pan. Examine and note the following:
   a. Shape of lungs and their relation to the position of the heart and the shape of the thoracic cavity.
   b. Smoothness of diaphragm, its position in relation to the lung, and the direction of muscle fibers.
   c. Division of lungs into lobes, the number of lobes in each lung compared to human lungs.
   d. Covering of lungs. What type of epithelial tissue is this?
   e. Trachea and the rings of cartilage. Are they complete? What is their purpose? Observe length, diameter and branching. Cut the membrane that is attached to the ends of the cartilage rings and examine the lining under a microscope. Dissect the tissue away from the trachea to locate a bronchus. Follow the branching until the divisions become too small to be seen easily.
   f. Blood vessels, large arties and veins. Note branching of and relationship to bronchus.
   g. Larnyx size, shape and supporting framework. Locate the lid-like structure guarding the aperture and learn its purpose.
2. Insert a piece of tubing into the bronchus which has not been dissected. Hold bronchus closely around the tube to prevent the loss of air, and inflate the lungs. Note that the lung inflates a lobe at a time. Stop blowing and see what happens.
3. Pinch the tissue between the fingers. How does it feel? Cut off a small piece of lung tissue and place it in a dish of water. What happens? Why the difference?

Conclusions:
1. List the tissues. List the parts of the respiratory system and the function of each.
2. Trace the path of air from the nose to the blood stream.
3. Show evidence that the lung consists of many air spaces rather than one large air space.
4. Explain the relationship of the lung covering to the lungs themselves and to the wall of the thoracic cavity.

EXPERIMENT 2 - The Breathing Process

The breathing system is the mechanism for supplying oxygen and removing carbon dioxide from the cells of the body.

Purpose: To study the mechanics of breathing.

Materials: Y-tube, 2 balloons, bell jar, rubber sheeting, limewater, paper bag, and piece of rubber tubing with pinch cock.

Procedure:

1. Mechanics of breathing: Make a model of the chest by assembling the Y-tube, to which the balloons have been attached, bell jar, and rubber sheeting. Attach a piece of rubber tubing with pinch cock to the top of the Y-tube. This may be used to simulate the glottis.
    - a. Move rubber sheeting (diaphragm) down with tube (glottis) open. What happens?
    - b. Move the rubber sheeting up with tube open. What happens? Repeat with tube closed. What happens? If the sides of the bell jar were movable to simulate rib action, correlate rib movement with diaphragm movement. What changes occur in the pressure in the thoracic cavity during the above activities?
2. Breathing rate: Work in pairs. Watch the rise of the chest and count the number of times for 1 minute. Repeat three or more times and record the average. Compare with records of classmates of both sexes. Compare rate to those of an adult, a person over 70 years of age, a child, and a young baby.
3. Control of the respiratory rate:
    - a. Chemical Regulation
        1. Breathe deeply with mouth open at the rate of 15 times per minute for two minutes. Is there a natural pause following this? Does it become more or less difficult to continue forcing your respiration? Do the forced respirations increase or decrease the CO_2 content of the blood?
        2. Breathe deeply with mouth open into a paper bag fitted snugly about the mouth and nose. Continue for 2 minutes. Compare the results with those in (1). What effect does this forced breathing have on the CO_2 content of the blood. Why?
        3. Hold your nose shut and hold your breath for ½ to 1 minute. Record rate. Does holding your breath increase or decrease the CO_2 content of the blood?
        4. Sit quietly and breathe normally for 3 or 4 minutes. Then hold your nose shut and hold your breath as long as you can. Record the time.

5. Breathe very deeply with mouth open at rate of 15 times per minute for 2 minutes. Pinch your nose shut and hold your breath as long as possible. Record the time and compare these results with those in (4). Explain.
6. Run in one place for 2 minutes. Stop and hold your nose shut and hold breath as long as possible. Record time. What effect does muscular exercise have on the CO_2 content of the blood?

b. Nervous regulation: What is the location of the respiratory center? From where does this center receive impulses? To what parts does it send impulses? List the function of each of the following cardiorespiratory mechanisms:
    (1) carotid sinus
    (2) Aortic arch reflex
    (3) lung reflex

What nerves exert a control on respiration?

Conclusions:
1. Explain the respiratory movements which are involved in inspiration and expiration.
2. What muscles are involved in these movements?
3. How often must these respiratory movements occur at your age to meet your needs?
4. What are the reasons for variations in respiratory rate?
5. Explain the chemical regulation of respiration.
6. What parts of the brain act as centers for respiratory control?
7. How do chemoreceptors and pressoreceptors function in regulation of respiratory rate?

EXPERIMENT 3 - Exchange of Gases in the Respiratory System

Breathing is only the means or mechanics of exchanging the gases in the lungs which in turn transports the gases to and from the individual cells. The gases actually exchange through the surfaces of the cells.

Purpose: To study the actual exchange and transport of the respiratory gases.

Materials: Spirometer, tape measure, thermometer, piece of glass or metal, 12-inch length of glass tubing, plastic refrigerator bag, air pump, cellophane, citrated animal blood, and solutions of bromthymol blue, methylene blue, and phenolphthalein.

Procedure:

1. Lung capacity
   a. Changes in thorax and abdomen:
   With a tape measure find the circumference of the chest at the axillary level and the umbilicus level for normal expiration, normal inspiration, forced expiration, and forced inspiration.
   b. Breathing volume (measured by a spirometer):
   Tidal air: Take a normal inspiration and breathe into the spirometer; record a cubic inch or cc of water displaced.
   Supplemental air (expiratory reserve amount): Take a normal inspiration, exhale normally, and then exhale into the spirometer all the air that you can force out before taking another inspiration. Record.
   Complimental air (inspiratory reserve amount): Inhale as deeply as possible and exhale into the spirometer normally; subtract from this the volume for tidal air. Record the difference.
   Vital capacity (the sum of the above volume): Inhale as deeply as possible and exhale as much as you can into the spirometer; record. How does this result compare to the sum of the three trials above? How do you account for any difference? Compare results with those of classmates of both sexes.
   Explain why residual and minimal air cannot be measured in this way.
2. Differences in inspired and expired air
   a. Temperature change: Take temperature of air in room. Record. Hold bulb of thermometer between lips and breathe on it. (Bulb must not be in mouth.) Record temperature of exhaled air. Explain results.
   b. Moisture content change: Breathe on the surface of a piece of cold glass. What collects on the surface? Explain.
   c. Carbon dioxide change: Hold a plastic refrigerator bag over nose and mouth and breathe into it for 1 minute. Remove bag from face, holding the open end of the bag tightly closed. Insert a funnel stem into the opening

and pour brom-thymol blue into the bag. Shake the bag. What change occurs? Pour some brom-thymol blue into an unused bag, shake it and observe for color change. Compare the two results.

d. Make a comparison chart to show the difference in the composition of inspired and expired air.

3. Gas exchange: Review diffusion by doing the following:
   a. Open a bottle of strong perfume or oil of peppermint at the front of the room. Can you detect it at the rear of the room? Explain.
   b. Take a large test tube of water. Add a few drops of 1% phenolphthalein solution. Cover the open end of the tube with wet cellophane. Fasten with a rubber band. Invert the tube over a bottle of ammonium hydroxide. Observe any change in color. Watch carefully for evidence of "molecules in motion."
   c. Review the principles dealing with concentration of particles and their subsequent movement (pressure or tension gradients). Apply the principles to the exchange of gases in the lungs.

4. Transport of gases: Review the blood vessels which carry the blood between heart and lungs and vice versa. Differentiate between arterial and venous blood.
   a. To demonstrate the effect of oxygen and carbon dioxide on the blood, do the following:
      (1) Half-fill two small flasks with animal blood.
      (2) Place a glass tube in each flask so that the lower opening is below the level of the blood.
      (3) Connect the tube of 1 flask to an air pump and pump air carefully and slowly into the blood for several minutes.
      (4) Into the second flask, blow air from your lungs for about a minute. Do it slowly in several breaths at nearly as normal rate as possible.
      (5) Compare the colors of the blood in the two flasks. How do you account for your observations? Can the colors be reversed? Try it.
   b. Oxygen transport: Test blood for hemoglobin and for coagulation time. If necessary, test blood for hematin (hemin) and oxyhemoglobin crystals. What difference in the structure of the crystals do you observe? What caused this difference?

Conclusions:
1. To meet physiological requirements, how much air is inhaled with each quiet respiration?
2. Define vital capacity.
3. Comparing the class results, what differences in vital capacity do you find?
4. Which lung capacity would be affected for athletes or someone playing a wind instrument? Explain.

5. What are the differences in composition between inspired and expired air? Is there a corresponding difference between arterial and venous blood? Explain.
6. Give evidence that there is a movement of particles through the membrane in Procedure 3. What have you learned about the pressure which takes place between blood and alveoli?
7. Explain how the specific direction in which the gases, oxygen, and carbon dioxide move is determined by the pressure differences of those gases in the blood and alveoli, and in the blood, tissue-fluid, and cells.
8. Differentiate between arterial and venous blood. Where does blood become each kind?
9. Which blood vessels of the pulmonary circulation carry arterial and which venous blood?
10. What role does hemoglobin play in the transport of oxygen and carbon dioxide?

RESOURCES

Textbooks:

Federal Aviation Administration, Physiological Training. Oklahoma City: Office of Aviation Medicine, Physiological Support Office, 1964.

Mohler & Siegel, Medical Facts for Pilots. Oklahoma City: Federal Aviation Administration.

Sanderson Films, Inc., Oxygen, Altitude and the Body.Wichita,Kansas. 1969.

Van Deventer, C.N., An Introduction to General Aeronautics. American Technical Society, 1965

Van Sickle, Neil D., Modern Airmanship. Princeton, N.J.: Van Nostrand. 1961.

Reference Books and Information:

Bernardo, James V., Aviation and Space in the Modern World. New York: E.P.Dutton & Company., 1968.

Best, C. H. and N.B. Taylor, The Human Body - Its Anatomy and Physiology.New York: Holt & Company, 1956.

*Federal Aviation Administration, Advisory Circulars:

00-2	"Advisory Circular Checklist," (Latest Revision)
20-32A	"Carbon Monoxide (CO) Contamination in Aircraft - Detection and Prevention," (9-13-68).
60-4	"Pilot's Spatial Disorientation," (2-9-65)
91-8	"Use of Oxygen by General Aviation Pilots/Passengers," (5-16-65).
91.11-1	Guide to Drug Hazards in Aviation Medicine, (7-19-63). ($0.35 GPO).

FAA, Airman's Information Manual, Government Printing Office, Washington, D. C. 20402 (Pt.1,$4.00; Pt.2,$4.00; Pt.3,$20.00)

Gerathewohl, Siegfried J., Principles of Bio-astronautics. Englewood Cliffs, N.J.: Prentice Hall

Medical Aspects of High Altitude Flight. Denver: Jeppesen & Co., 1958

Morrison, Thomas F., F. D. Cornett, and J.E.Tether, Human Physiology. New York: Holt, Rinehart, and Winston, 1963.

National Aeronautics and Space Administration, available from Government Printing Office, Washington, D. C. 20402.

NASA SP-47 Space Cabin Atmosphere - Part I: Oxygen Toxicity, 1964, 51 pages.

NASA SP-103 Human Response to Sustained Acceleration. 1966, 136 pages.

NASA SP-4003 Space Medicine in Project Mercury. 1965, 198 pages

NASA SP-5006 The Measurement of Blood Pressure in the Human Body.1964, 34 pages.

*NF-27 "Living in Space." Free from NASA Center facilities.

Ordway, F.I., J.P. Gardner, and M. R. Sharpe, Basic Astronautics. Englewood Cliffs, New Jersey: Prentice-Hall, 1962.

United States Air Force, Your Body In Flight, AFP-160-10-3. ($1.00 GPO).

*Refer to Reading List in back of Course of Study for Addresses. (See pages 233 and 244)

PHYSIOLOGY OF FLIGHT

Films:

*Federal Aviation Administration:
  "Charlie," (FA-618). Effects of alcohol on flight. 1967, color, 22mm
  "R_x for Flight," (FA-606). Aero-medical problems and the general aviation pilot. 1966, Color, 18mm
*National Aeronautics and Space Administration:
  "Food for Space Travelers," (HQk-SR3). 1966, 28 min.
  "Space Medicine," (HQk-SR8). 1966, 28 min.
  "Living in Space," 3 parts (HQ-131-A,B,and C). 1965, color, 12, 20 and 12 min. respectively.
*U. S. Air Force:
  "The Universe Within," (SFP 1313). Color or B/W, 14 min.
  "The Perception of Orientation," (TF 6050).

Other Aids:

*Sanderson Films, Inc.:
  "Oxygen, Altitude and the Body", filmstrip, recording and booklet.
  "Oxygen Systems", filmstrip, recording and booklet.

* See pages 233 and 234 for addresses.

INTRODUCTION

This unit applies much of the knowledge learned in earlier units, especially material contained in the principles of flight and the physiology of flight. The subjects covered in this present unit bring in additional material about our universe, the solar system, propellants, orbits, rockets, satellites, and manned space flight. All of these rely to some extent on material covered in previous lessons and are intended to enable the student to study at greater depth the sciences involved.

Today, with interplanetary travel almost within grasp, man stands upon the threshold of an experience that has no precedent. Therefore, the airman of today who will perhaps be the spaceman of tomorrow needs to know the medium in which he will be operating and certainly to know something about the problems that every citizen will be asked to help solve.

We are grateful to NASA for allowing us to use demonstration sheets from the NASA Spacemobile Discovery Workshop. These are to be found at the end of this unit.

TO THE TEACHER

This unit includes not only history but current events, for the space program will, itself, provide new and exciting data.

The following concepts can be developed in teaching this unit:

1. The space program is based heavily on physics and mathematics and the more the student learns about the inter-relationship of all the sciences the more he can learn about and contribute to the space program.

2. Even without an advanced knowledge of the sciences, the man in space program can be fascinating.

3. An understanding of how the achievements and knowledge learned from aviation and the sciences have combined to make the man in space program possible.

4. The space program has produced many by-products of this special knowledge; for example, new plastics and metals, advanced communications equipment, automated aids for invalids, photographic advances, weather analysis, and food preparation.

5. Nearly every profession can be connected or applied to aerospace programs and industries; therefore, the opportunities for employment in this field are quite vast. To name a few, they are psychologists, physiologists, mathematicians, engineers, designers, computer technicians, anthropometrists, flight personnel.

6. Man is an integral part of the complex system that carries him into space. He adds reliability and flexibility to an almost perfect system. It is his ability to make decisions and override an automated system, if it malfunctions, that make him indispensable.

7. Since both man and machines possess individual characteristics that surpass the other, an important objective in the realm of human factors engineering necessitates designs that utilize the combined talents of each.

The teacher has some excellent material and sources available to supplement material presented in this unit. Many military installations and aerospace industries provide field trips and guest lecturers for special programs. The NASA Spacemobile and the Air Force lecture team from the Air University and Maxwell Air Force Base are examples of excellent school-wide programs that are available if requested in advance. NASA materials (see "Resources" at the end of this unit) are excellent. Up-to-date publications and film lists should be requested from NASA at least once a year.

UNIT OUTLINE

I. EARLY CONCEPTS OF SPACE TRAVEL

American Heritage History of Flight, pp. 30, 35, 101
Von Braun, pp. 6-21
NASA, Space: The New Frontier, p. 12

- A. First thoughts of space flight--mixture of imagination and vague concepts
  - 1. 160 B.C., "Cicero's Republic,"
    - a. Gave a concept of a whole universe
    - b. Realization of the insignificance of the earth
    - c. Visualization of stars never seen from earth

Misenhimer - Man in Space Unit.

  - 2. Stories of flights to the moon
    - a. 160 A.D., Lucian of Greece
    - b. Francis Godwin in the early 17th century
  - 3. Renaissance of science renewed interest in travel to other worlds
    - a. Copernicus
    - b. Keppler
    - c. Newton
    - d. Galileo

Film, "A View of the Sky"

  - 4. Voltaire, Dumas, Jules Verne, Edgar Allen Poe, H.G. Wells, gave to literature tales of space travel
  - 5. Edward Everett Hale's The Brick Moon, 1869
    - a. First known presentation of man-made satellite into orbit
    - b. Discussed manned orbital laboratory, weather communications, navigation satellites

Better known for his book, Man Without A Country

II. THE SOLAR SYSTEM

"Until man has first solved the perplexingly complex problems concerning the earth's solar system, he cannot intelligently determine the means by which intergalactic travel and communication will be accomplished."

Bryan, p. 121

- A. Composition of the solar system
  - 1. The sun, nine planets and their moons, asteroids, comets, meteroids, and dust
  - 2. All nine planets move around the sun in the same direction and in nearly circular paths

Glasstone, pp. 375-448
Bryan, pp. 121-123

Space: The New Frontier, pp. 16-24

3. Diameter of solar system is 7.3 trillion miles	Earth and Space Science, A Guide for Secondary Teachers, pp. 53-71
B. The Sun 1. Physical characteristics 2. Surface and atmospheric phenomena	Plan a trip to a planetarium if at all possible
3. Planets held in orbits by sun's gravity	Glasstone, pp. 292-309
C. The Moon 1. Physical characteristics 2. The lunar surface 3. Effect on ocean tides	Glasstone, pp. 578-663
D. The Stars and the Milky Way 1. Characteristics 2. Magnitude 3. Stellar motions and their effects 4. Tools of the astronomer	Glasstone, pp. 812-820
E. Planets of the Solar System 1. Names and distances from sun 2. Interest in search for life on other planets	Glasstone, pp. 664-761 Yale, - - - - "Search for Extra-Terrestrial Life," Bryan, p. 122
F. Asteroids, comets, and meteorites	Demonstration # 1
G. Earth's atmosphere and how far man has penetrated it 1. Troposphere 2. Stratosphere 3. Mesosphere 4. Thermosphere 5. Exosphere 6. Terrestrial space 7. Earth's radiation belt	Bryan, p. 123
III. ROCKETS	
A. Definition 1. A rocket is a reaction device 2. Although a rocket is a reaction device, not all reaction devices are rockets 3. A rocket contains all the elements it needs to operate, including both fuel and oxygen	Works in accordance with Newton's Third Law of Motion Demonstrations #2, 3, and 4 A jet engine, by contrast, is a reaction device that uses oxygen in the air to support the combustion of the fuel carried on board. Von Braun, p. 22; Bernardo, pp. 169-170.

B. History
  1. In 1232, Chinese repelled Mongols with "arrows of flying fire"
  2. Rockets used in Venetian-Genovese War, 1379
  3. Congreve's rockets
     a. Solid propellant rocket
     b. Used in Napoleonic Wars and War of 1812
     c. Razed greater part of Copenhagen in 1807
     d. Congreve's rockets fired by the British during the siege of Ft. McHenry in 1814
     e. Adapted to humanitarian purposes - breeches buoy
  4. Hermann Oberth (Rumanian-German), Constantin Tsiolkovsky (Russian), and Robert H. Goddard (American), working separately, laid foundation for modern rocketry
  5. First liquid-fueled rocket launched March 16, 1926, rose to 41 ft., covering 184 ft.
  6. Rocket-powered autos and railway cars tested in Germany by Opel in 1928
  7. First rocket powered airplane flown by Opel in 1928 using 16 rockets,each producing 50 lb. thrust
  8. First instrumented launch, using barometer, thermometer, camera, July 17, 1929
  9. Rocket reached 7500 ft. and 700 mph in 1935
  10. Rockets used in World War II
      a. German V-2
      b. Japanese Kamikaze planes
      c. British anti-aircraft rockets
      d. American Bazooka
      e. Barrage rocket
      f. JATO
  11. Improvements since then have led to all sizes and kinds of rockets and larger missiles to launch satellites

NASA, Space: The New Frontier, pp. 12-16
Von Braun, pp. 23-39
Bryan, p. 124

"Rocket's red glare" in "Star Spangled Banner"

Von Braun, pp. 40-59
Bryan, p. 124
NAEC, Portfolio No. 1, "Robert H. Goddard," and "Robert H. Goddard, 'Father' of Modern Rocketry"
Walters, Helen, Herman Oberth: Father of Space Travel
NASA, Space: The New Frontier, pp. 14-15

Von Braun, pp. 67-85

Von Braun, pp. 87-89, 94, 96, 101
Bryan, p. 125

C. Propellants
  1. Solid chemical
  2. Liquid chemical
  3. Nuclear
  4. Photon and Ion

Glasstone, pp. 83-173
Bryan, pp. 125 - 126
Hunter, Thrust Into Space
Demonstration #5
NASA Filmstrip, "Don't Build That Rocket Alone"

D. Guidance systems
  1. During launch phase
  2. Mid-course guidance
  3. Types of guidance systems
    a. Command guidance system
    b. Target-seeking or homing guidance
    c. Inertial guidance
    d. Celestial guidance

Glasstone, pp. 174-216
Bryan, pp. 127-128

E. Tracking
  1. Launch-site tracking
  2. Space tracking
  3. Networks
  4. Laser Tracking

Glasstone, pp. 217-227
Thomas, Satellite Tracking Facilities
NASA Film, "The World Beyond Zero," 29½ min. Color

IV. UNMANNED SATELLITES, SOUNDING ROCKETS, LUNAR AND INTERPLANETARY SPACECRAFT

NASA FACTS "Orbits and Revolutions"

A. Orbit: A path in which a body moves in relation to its source of gravity. Four types:
  1. Circle
  2. Elipse
  3. Parabola
  4. Hyperbola

Glasstone, pp. 41-81
Bryan, p. 128
Four types named after the conic sections--the four basic curves derived from intersecting a cone with a plane

B. Launching a satellite into orbit
  1. Effect of gravity
  2. Orbital velocity
  3. Gravity versus kinetic energy
  4. How a satellite is made to "stand still"

Newton's Laws of Gravity and Motion; Keppler's 3 laws
Demonstration # 6

C. Scientific satellites
  1. Unmanned scientific satellites
    a. Gather data while in orbit around the earth
    b. Have, for example, made it possible for scientists:
      (1) to learn that the earth is slightly pear-shaped
      (2) to recognize the existence of Van Allen Radiation (Explorer since 1958)

Glasstone, pp. 240-290
NASA, Space: The New Frontier, pp. 30-37 and "This is NASA"

Von Braun, pp. 176-189
Bryan, pp. 134-138
Bernardo, pp. 188-196

3. to find that sunlight exerts pressure
4. to study the effects of tiny bits of matter in space (micrometeroids)
5. to study the weather
6. to establish new means of communications
7. to establish a new navigation aid
8. to study other sciences through the use of orbiting satellites

2. Sounding rockets
   a. Explore the upper atmosphere but do not go into orbit
   b. Purpose: to refine techiniques for further satellite and manned space explorations
   c. Tests using small sounding rockets
      (1) flight components
      (2) design of next generation rocket systems
      (3) new receiving, tracking, and data reduction components
   d. Large meteorological sounding rockets program
      (1) devoted to improvement of experimental techniques
      (2) actual exploration of the upper air

D. Unmanned lunar and interplanetary spacecraft
   1. Escape velocity
   2. Ranger Spacecraft
      a. Have gathered data about the moon and tested space technology since 1961
      b. Ranger VII took TV pictures of the moon right up to impact (July 31, 1964).
   3. Surveyer Spacecraft
      a. Soft landings as contrasted with crashing impacts of Ranger
      b. Both Surveyors transmitted pictures
      c. Latest Surveyor dug into the surface for soil analysis
   4. Lunar Orbiter
      a. Has been sent into orbit around the moon
      b. Will obtain photographs of the surface to help select landing sites

If time permits, discuss weather satellites and communications satellites.

Explorer, Pioneer, Project Score, Discoverer
NASA FACTS, "Explorer XXIX (the Geodetic Explorer)", "Pioneer," and "Putting Satellites to Work."

Von Braun, pp. 191-195 discusses both U.S. and Soviet rockets and satellites.
Glasstone, pp. 30-31
NASA, Space: The New Frontier, pp. 37-41

Discuss ways to study temperature, wind, radio attenuation measurements and ambient pressures.

Von Braun, pp. 150-157

NASA, Space: The New Frontier, pp. 28-29, 42-49

NASA, "This Is NASA," p.9
Bryan, pp 138-139
Bernardo, pp. 187-188

5. Mariner II
   a. Flew past Venus at a distance of 21,648 miles in 1962
   b. Transmitted data on the planet's surface temperature, magnetic field, and atmospheric composition

NASA, "A Report from Mariner IV" and "Mariner Spacecraft"

6. Mariner IV
   a. Made a 228-day, 325-million mile trip to Mars in 1965
   b. Transmitted 21 photographs of the planet to earth

V. MAN IN AIRCRAFT SYSTEMS

A. Object of concern with man in an aircraft or spacecraft comes from trying to achieve the best overall, integrated man-machine system.

   1. At one time, only engineers made an attempt to do this, but were inadequately trained.

   2. Systems became too complex for man to operate safely 100% of the time.
   3. Many disciplines began taking man's capabilities and limitations into account - psychologists, physiologists, M.D.'s, engineers, etc. (Basis of formation of the Human Factors Society and Human Factors Engineering groups in industry (multi-disciplinary); also Aerospace Medical Association.)

B. Fitting man-machines-environment together calls for concern with several problem areas.

   1. Environment
      a. Acceleration loads due to maneuvering, pullouts from dives, dogfights, missile evasion, booster lift-off, atmospheric reentry. (Research on "G" forces effects on man; development of anti-G

      b. Vibration from engine and turbulence and effects on vision; vibration major problem in helicopters, during s/c boost.

Burns, N.M - Unusual Environments

   c. Noise and ear damage or communication interference
   d. Need for oxygen due to high altitude operations; pressure suits.

2. Aircraft control and spacecraft control
   a. Handling qualities
   b. Stabilization assist devices
   c. Stall and stress limits
   d. External vision requirements

3. Control/Display Integration

Reference: Human Factors Journal (most issued)

   a. Control forces, displacements and feel
   b. Type of controller (stick, wheel and column, side-stick)
   c. Pilot information needs via displays
   d. Proper display encodement
   e. Reduction of display clutter by eliminating information not required
   f. Color cues
   g. Acoustic displays

4. Mission Requirements
   a. Long duration flight - implications for rest, relief, and feeding provisions.
   b. Low altitude, high speed flight - how to avoid ground impact; how to assist pilot by automation; how to best attain check-point and target location.
   c. Night flying and day flying - lighting problems, glare, night vision
   d. Weapon delivery

5. Safety of Flight
   a. Cue conflict
   b. Disorientation
   c. Seating orientation and motion sickness
   d. Clear air turbulence
   e. Escape from crippled vehicle
      (1) Ejection seats - up or down
      (2) "G" loads windblast and impact
      (3) Eject entire crew capsule if multi-man crew
      (4) Ejection altitude envelope
   f. Collision avoidance - more critical and difficult with faster and larger aircraft such as SST's
   g. Air traffic control
   h. Accident investigation

C. To achieve the maximum man-machine functioning, crews must be carefully selected and intensively trained.

NASA, "NASA Astronauts"

1. Personnel selection - best man for best job
   a. Establish criteria
   b. Personality and aptitude tests
   c. Achievement tests
2. Training
   a. Establish desired proficiency level
   b. Use realistic training devices
      (1) Part task trainers
      (2) Complete mission simulators

VI ROCKET RESEARCH AIRCRAFT, EXPERIMENTAL AIRCRAFT, AND STRATOSPHERIC BALLOON FLIGHTS

A. Rocket research aircraft

1. Purpose is to push into new regimes of altitude and speed

   Gantz, Man in Space

2. MX-324, first American liquid-rocket aircraft

   Perry, "The Antecedents of the X-1."

3. X-1 - Bell
   a. X-1A, used for exploration of higher speeds (Mach 2) and altitudes (90,000 ft.) than the original could reach

      Were three X-1's, then modified

   b. X-1B intended specifically for studies of aerodynamic heating effects and pilot trainer for X-2
   c. X-1E, a completely rebuilt X-1 capable of Mach 3

      Never flew that fast because roll coupling effects made it unstable above Mach 2

   d. Chief pilot, Charles Yeager
   e. Dropped from B-29 at 30,000 ft.
   f. All X-1's had four rocket motors each with 1500 lb. thrust
4. D-558 - Douglas
   a. D-558I, turbojet powered, capable of high subsonic speeds
   b. D-558II was rocket version
   c. First pilot, Bill Bridgeman
   d. Also dropped from B-29
   e. First swept-wing rocket aircraft
   f. In 1953 set altitude record of 83,235 ft. and speed record of 2.04 Mach
5. X-2 - Bell
   a. Designed to explore above 10,000 ft. and Mach 3
   b. Dropped from B-50
   c. First throttable rocket engine in U.S.rocket aircraft

- d. Attained a performance of 2,095 mph, 126,200 ft.
- e. Detachable cockpit
- f. Two built; one lost by explosion, one by loss of control

6. X-3 - Bell
    - a. Intended to be first supersonic aircraft
    - b. Engines that would have made it capable of supersonic speeds were never delivered
7. The X-15 - designed to test high speed aerodynamics and effects on materials
    - a. Weight, 33,000 lbs. at launch, 14,700 lbs. at landing
    - b. Rocket engine, 17,000 to 57,000 lb. thrust
    - c. Climb 6600 ft/sec; ceiling, 250,000 ft.
    - d. Withstand temperature of 1200°F
    - e. Heat treated Inconel X, nickel-steel alloy
    - f. Painted black to radiate heat
    - g. Titanium in inner wing; aluminum where excessive loads and heat are not encountered
    - h. Ballistic trajectory--going outside aerodynamically effective atmosphere
    - i. Controlled by reaction control jets of 40 and 110 lb. thrust

Stillwell, X-15 Research Results
Gantz, pp. 215-221
Bernardo, p. 196

Film, "Research Project X-15"

Bryan, p.141

8. Assignment of X-15 in research
    - a. Structures (heating and vibration)
    - b. Operational and control problems at higher speeds
    - c. Hypersonic aeronautics
    - d. Photographic flights to above 40 miles
    - e. Bioastronautics

X-15 #2 rebuilt to attain Mach 8.0. Have students discuss exit and reentry to earth's atmosphere through varying angles of attack

Radiation, weightlessness

9. XB-70 - North American
    - a. Originally conceived as an intercontinental bomber
    - b. Decision made in 1963 to produce only two aircraft
    - c. High-speed, high-altitude six-jet aircraft; performance, 2000 mph, 70,000 ft. altitude
    - d. 70% of structure is stainless steel honeycomb, entire forward section is made of titanium

- e. Design features
  - (1) canard on the forward fuselage
  - (2) wing tips that fold downward during high speed flight to increase directional stability
  - (3) use of the "compression lift" principle to enable the aircraft to "ride" its own shock waves at high Mach numbers
- f. No. 2 plane and its F-104 chase plane collided on June 8, 1966, during flight to allow photographic coverage of engines
  - (1) both planes destroyed
  - (2) one B-70 pilot ejected safely, other killed; F-104 pilot killed

Al White survived; Maj.Carl Cross and Joseph A.Walker killed

B. Experimental aircraft

1. Represent approaches to new aerodynamic principles and techniques
2. X-4
   - a. Two turbojets, no horizontal stabilizer
   - b. Nothing more than attempt to refine 5-year old concepts

Concepts originated by Lippisch and rediscovered by John Northrop

3. X-5
   - a. Variable sweep wing
   - b. Progenitor of TFX and Boeing SST
4. XF-92A
   - a. Delta wing
   - b. Progenitor of F-102A, F-106, B-58
5. Early experimental planes (1944-1946)
   - a. Extended frontiers from subsonic to Mach 3, 40,000 ft. to 100,000 ft.
   - b. Uncovered new problems and solved old ones
   - c. Validated wind tunnel experiments
6. The Lifing Body

C. Stratospheric balloon flights

Simmons, Man High
Garathewohl, Principles of Bioastronautics

1. First studies by man of upper atmosphere
   - a. Began in 1931 with August Piccard
   - b. He and his wife set the first high altitude balloon flight using an enclosed capsule
2. U.S. Navy Strato-Lab tested physiological responses of crew above 100,000 ft.
3. Project Excelsior: Free fall from 100,000 ft. with anti-spin equipment

4. U.S. Air Force "Man High"
   a. Purpose to investigate effect of cosmic rays; later included technical, physiological, and psychological studies at record altitudes
   b. Lofted to 100,000 (+) ft. by 3 million cu. ft., 1½ mil thick, helium filled polyethylene balloon
      (1) 200.2 ft. fully inflated
      (2) weighed 960 lbs.
      (3) measured 280 ft. long at launch
   c. Used air regeneration. Anhydrous lithium chloride with anhydrous magnesium perchlorate to maintain minimum humidity; carbon dioxide removed by anhydrous lithium hydroxide--100% oxygen
   d. Ascent of Demi McClure, August, 1957
      (1) Accident with parachute
      (2) At 35,000 ft. hit jet stream with sheet 500 mph winds, damaged balloon
      (3) At 99,700 ft. cabin temperature rose as did pilot's temperature
      (4) Pressure problems in descending

Excess of sweat during parachute repacking caused more body heat to be turned out; overburdened air regeneration system.

VI. MANNED SPACE EXPLORATION

A. Project Mercury
   1. First program of NASA to orbit a manned spacecraft
   2. Scientific Objectives:
      a. To determine man's capability in a space environment
      b. To determine man's reactions while entering and returning from space
   3. Necessary research and development
      a. Aerodynamically stable and sealed vehicle
      b. Launch vehicles
      c. Communications and tracking systems
      d. Test procedures - man and machine
      e. Recovery and survival techniques
      f. Selecting and training
         (1) astronauts
         (2) scientists
         (3) ground support personnel
   4. Missions
      a. Suborbital mission
         (1) first U.S. manned flight by Alan Shepard, Jr. on January 31, 1961

NASA, "Manned Space Flight (Mercury and Gemini)," pp. 1-3
Bryan, pp. 141-144
Swenson, This New Ocean: A History of Project Mercury
Gerathewohl, p. 486
Glasstone, pp. 38-40, 860-866
Bernardo, pp. 175-176
NOTE: NASA films are available on each space flight; request current film list.

(2) 15 min., 116 miles into space, down range 302 miles
(3) second suborbital flight by Virgil I. "Gus" Grissom on July 21, 1961
(4) 118 miles into space, 301 miles down range
b. Orbital flights
(1) Chimpanzee Enos, November 29, 1961, two orbits
(2) MA-6, February 20, 1962, John Glenn first American in orbit, three orbits
(3) MA-7, May 24, 1962, Scott Carpenter, three orbits
(4) MA-8, October 3, 1962, Walter Shirra, Jr., six orbits
(5) MA-9, May 15-16, 1963, Gordon Cooper, twenty-two orbits, 34½ hours

B. Project Gemini
1. Purpose of project was a series of scientific, biological and technological experiments
a. To determine man's capability to live and work in space
b. Capability to dock with other spacecraft

NASA, "Gemini Pictorial," and "Manned Space Flight (Mercury and Gemini)," pp. 3-8
Bryan, pp. 144-146
Glasstone, pp. 867-870
Gerathewohl, pp. 631-534
Bernardo, pp. 176-178

2. Research and development
a. Two-man craft followed Mercury's basic design but larger and twice as heavy

7.5 ft. wider; 11.5 ft. taller, weighed 7700 lbs.

b. Launch vehicle
(1) modified Titan II
(2) total thrust 530,000 lbs.
c. Agena D chosen as "Target" vehicle for docking missions
3. Missions
a. GT-3, March 23, 1965
(1) Astronauts Virgil Grissom and John Young
(2) 3 revolutions, 4 hrs., 54 min.
(3) America's first two-manned space flight
b. GT-4, June 3, 1965
(1) James McDivitt, Edward White
(2) 62 revolutions, 97 hrs., 56 min.
(3) first walk in space by American astronaut
(4) first extensive maneuver of spacecraft by a pilot
c. GT-5, August 21, 1965
(1) L. Gordon Cooper, Charles Conrad, Jr.
(2) 120 revolutions, 190 hrs., 55 min.
(3) proved man's capacity for sustained functioning in space environment

- d. GT-7, December 4, 1965
  - (1) Frank Borman, James Lovell
  - (2) 330 hrs., 35 min., 206 revolutions
  - (3) World's longest manned orbital flight
- e. GT-6, December 15, 1965
  - (1) Walter Schirra, Jr., Thomas Stafford
  - (2) 16 orbits, 25 hrs., 51 min.
  - (3) World's first successful space rendezvous
- f. GT-8, March 16, 1966
  - (1) Neil A. Armstrong, David R. Scott
  - (2) 6.5 revolutions, 10 hrs., 41 min.
  - (3) World's first successful docking in space
- g. GT-9, June 3, 1966
  - (1) Thomas P. Stafford, Eugene A. Cernan
  - (2) 45 orbits, 72 hrs., 21 min.
  - (3) Three rendezvous of a spacecraft and a target vehicle. Longest extravehicular exercise.
- h. GT-10, July 18, 1966
  - (1) John W. Young, Michael Collins
  - (2) 43 orbits, 70 hrs., 47 min.
  - (3) First use of target vehicle as source of propellant power after docking; new altitude record of 475 mi.
- i. GT-11, September 12, 1966
  - (1) Charles Conrad, Jr., Richard F. Gordon, Jr.
  - (2) 44 orbits, 71 hrs. 17 min.
  - (3) First rendezvous and docking in initial orbit; first multiple docking in space; first formation flight of two space vehicles joined by a tether. Highest manned orbit--apogee about 850 mi.
- j. GT-12, November 11, 1966
  - (1) James A. Lovell, Jr., Edwin A. Aldrin, Jr.
  - (2) 59 orbits, 94 hrs. 35 min.
  - (3) 5½ hr. extravehicular walk and work; first photograph of a solar eclipse from space.

4. Summary of accomplishments
   - a. Demonstrated performance of Gemini spacecraft
   - b. Evaluated performance of rendezvous guidance and navigation
   - c. Provided information on long-duration flights
   - d. Rendezvous and docking in space with target vehicle
   - e. Maneuvering in space (before and after docking)
   - f. Determined man's abilities in space over extended time
   - g. Controlled earth landing at pre-selected site

C. Project Apollo	
1. Goal is to put men on the moon and return them safely to earth	Gerathewohl, pp. 534,549 NASA, "Manned Space Flight (Apollo)," and "Man in Space"
2. Key maneuver will be the technique of orbital rendezvous	
3. Spacecraft is blunt-cone shape different from bell-shaped Mercury and Gemini vehicles	NAEC, "Project Apollo" Chart Bryan, p. 146
4. Launch vehicles	Glasstone, pp. 870-880
a. Saturn I, 1.5 million lbs. thrust	Bernardo, pp. 190-202
b. Saturn IB, Apollo launch into earth orbit	NASA films, "Power for the Moonship"
c. Saturn V, 3 stages, earth orbit to moon	"Room at the Top " *Above and Beyond*, V.1 pp. 162-184
(1) 1st stage: 5 F-1 engines, combined thrust of 7.5 million pounds.	
(2) 2nd stage: 5 F-2 engines, combined thrust of 1 million lbs.	
(3) 3rd stage: one J-2 engine, 200,000 lbs. thrust	
5. Flight profile sequence	NASA Film, "Returning from the Moon"
a. Inclined earth orbit	
b. Lunar trajectory	
c. Rearrange Command Module (CM) and Lunar Excursion Module (LEM) nose to nose	
d. Midcourse corrections (after 45 min. flying time)	
e. Lunar orbit at 100 miles	
f. Two crew members enter LEM	
g. Detatch LEM from CM and decelerate to descend to moon's surface	
h. Landing and exploration	
i. Launch LEM when CM is in sight	
j. Dock with CM and enter CM through Service Module (SM)	
k. Leave LEM in space to orbit moon	
l. Jettison SM before re-entry	
6. Re-entry	
a. 30-mile corridor	
b. Direction of re-entry controlled by rotating CM so that center of gravity is either above or below thrust line	
c. Too shallow re-entry might result in a skip out into space and helicentric orbit	
d. Too deep re-entry would result in burnup	

7. Unmanned Apollo Flights:

Above and Beyond, V.11, pp. 2011-2014; NASA (pamphlet "Apollo Historical Summary"

- a. AS-201, February 26, 1966
  - (1) Saturn IB
  - (2) Altitude 306 miles; distance 5,400 miles
  - (3) Suborbital Lob Shot to position spacecraft and Earth re-entry heat shield test.
- b. AS-203, July 5, 1966
  - (1) Saturn IB
  - (2) Altitude 115 miles; distance 117 miles
  - (3) Test liquid hydrogen behavior simulation of Saturn V restart conditions.
- c. AS-202, August 25, 1966
  - (1) Saturn IB
  - (2) Altitude 17,800 miles
  - (3) Suborbital flight to test spacecraft heat shield and check launch vehicle.

NOTE: January 27, 1967 Apollo (AS-204), scheduled to be first manned flight; tragic fire resulted in death of astronauts Grissom, White and Chaffee. Apollo program delayed one year.

Above and Beyond, V. 1, p. 168

- d. Apollo 4 (AS-501), November 9, 1967
  - (1) Saturn V
  - (2) Apogee of 9,767 N. miles reached with service module (SPS)
  - (3) Test of lunar vehicle and spacecraft systems. Third stage engine restarted after second revolution apogee. Altitude of miles attained.
- e. Apollo 5 (AS-204), Jan. 22, 1968
  - (1) Saturn IB
  - (2) Apogee 120 miles; perigee 88 miles
  - (3) Orbital tests of lunar module (LM) propulsion systems and second stage propellant dump experiment
- f. Apollo 6 (Project numbers discontinued with Apollo 6)
  - (1) Saturn V
  - (2) Apogee of 12,000 N. miles reached with LM
  - (3) Demonstration of launch vehicle and spacecraft systems performance.

8. Manned Apollo Flights	NASA (pamphlet) "NASA Manned Space Flights"
a. Apollo 7, October 11-22, 1968	
(1) Astronauts: Walter M. Schirra, Donn Eisele and Walter Cunningham	
(2) 163 revolutions, 260 hours, 8 min.	
(3) First manned Apollo flight	
(4) First live television from a manned vehicle	
b. Apollo 8, December 21-27, 1968	
(1) Astronauts: Frank Borman, James A. Lovell, Jr., and William Anders	
(2) 10 revs. of Moon, 147 hrs. 11 seconds.	
(3) Lunar and Earth photography; live TV broadcasts	
c. Apollo 9, March 3-13, 1969	
(1) Astronauts: James A. McDivitt, David R. Scott and Russell R. Schweickart	NASA Film: "Apollo 9: The Space Duet of Spider and Gumdrop"
(2) 151 revs. of Earth, 241 hrs. 53 seconds	
(3) 6-million mile Earth orbital mission	
(4) First all-up manned flight of the Apollo Saturn V space vehicle.	
(5) First manned flight of lunar module	
(6) First Apollo EVA (Extravehicular activities); rendezvous and docking	
(7) Live television, photographic surveys of Earth and observation of Pegasus II satellite and Jupiter	
d. Apollo 10, May 18-26, 1969	NASA Film: "Apollo 10: Green Light for Lunar Landing"
(1) Astronauts: Thomas P. Stafford, John W. Young and Eugene A. Cernan	
(2) 31 revs. of Moon. 192 hrs. 3 min.	
(3) Man's second lunar orbital flight	
(4) Passed within 9 miles of lunar surface of dress rehearsal of actual lunar landing mission of Apollo 11	
(5) Transmitted 19 live color TV transmissions	
(6) Splashed down within 7,000 yards of its primary recovery ship in the Pacific Ocean.	

e. Apollo 11, July 16-24, 1969	NASA Film: "Eagle Has Landed -- The Flight of Apollo 11.
(1) Astronauts: Neil A. Armstrong (Spacecraft Commander), Edwin E. Aldrin (lunar module pilot) and Michael Collins (Command module pilot)	
(2) Duration of flight 195 hrs., 17 min., 25 seconds.	
(3) Circled the Moon and undocked LM (lunar module)	
(4) Descent to lunar surface and touchdown (July 20, 1969)	
(5) Neil Armstrong -- first man on the Moon. Edwin Aldrin followed shortly.	See box on p.142 for Apollo 11 Lunar Surface Activity Time Schedule.
(6) Armstrong's first words after touchdown: "Houston, Tranquility Base here. The Eagle has landed."	
(7) Lunar activities: Planted the American Flag; live TV transmissions; first telephone call from President Nixon; collected rock samples for science; conducted several scientific experiments	
(8) Returned to lunar orbit and docked with the command/service module (CSM)	
(9) Returned to Earth -- Pacific Ocean landing.	
f. Apollo Flights 12 through 20 will extend the domain of terrestial life throughout the solar system.	NASA, "In This Decade..." Mission to the Moon - GPO - $1.25
(1) Scientific experiments on different areas of the Moon	
(2) Orbital Workshop to be established 200 miles from Earth; size comparable of a 2-story house where astronauts may live and work without cumbersome space suits; first mission 26-day duration -- later missions by a different crew will extend stay time to 56 days	Kirschner, Edwin J., "Mobility for Moon Exploration"
(3) Solar observations	
(4) Earth-orbiting space station; twelve-man crew. By mid 1980's this could be permanent station manned by 100 astronauts and scientists.	

(5) Space shuttle -- comparable size of DC-3 (the pioneer of commercial air transport)--capable of carrying 25,000 pounds of cargo or people between Earth and the orbiting base.

9. Precious Cargo:
   a. About 50 pounds of Moon surface was vacuum sealed on the Moon and later transported to Lunar Receiving Laboratory (LRL) at Houston, Texas, in two separate boxes on two separate aircraft.

      NASA, "In This Decade..." Mission To The Moon, $1.25, GPO

   b. Quarantined - 45 to 60 days at LRL
   c. Vacuum packed samples were then distributed to 140 scientists, LRL retained part of the total sample for subsequent experimentation.

      NASA, "Log of Apollo 11" - Publication. EP-72, 1969

   d. Evaluation and testing of lunar materials was done at LRL and at laboratories and universities around the world.
   e. Samples are preserved for posterity, sealed in a vacuum container and placed on public view.

10. Planetary probes:
    a. 1969 - Two Mars probes, Mariner 6 and 7, within 2,000 miles of Mars' surface July/August 1969;
    b. 1971 - Two orbiters will close toward Mars' surface for purpose of mapping Mars;
    c. 1973 - Two instrumented spacecraft will touchdown on Mars sending a probe to Jupiter for the first direct measurements of that huge planet.
    d. 1977 - "Grand tour" of the solar system by unmanned probe, passing by Jupiter, Saturn, Uranus and Neptune -- Flight will last for years.
    e. 1980's - First manned expedition to Mars could be setting off on the voyage to Mars.

D. Hazards of space travel

"Ten Steps Into Space" and "Earth and Space Science, pp. 76-80
NASA Facts, "Living In Space"
Glasstone, pp. 881-901

1. Weightlessness
    a. A condition in which no acceleration whether of gravity or other force can be detected by an observer within the system in question
    b. External forces produce no stress on the body
    c. Sustained weightlessness can only be studied in a vehicle that can:
        (1) leave the earth's gravitational field
        (2) circle the earth in an orbit where centrifugal force balances the earth's gravitational field
    d. Man's movement under 1/6 gravity
        (1) Astronauts: Armstrong and Aldrin walk on Moon easier than was expected.
2. Acceleration

NASA, Space Medicine in Project Mercury and The Measurement of Blood Pressure in the Human Body

    a. At blast-off
        (1) astronaut experiences transverse g forces from chest to back.
        (2) For first 70 seconds of flight, space vehicle accelerates at .1 g/sec. until it reaches peak of 7. g, then decelerates at 3g/ sec. until it reaches 1.8 g.
    b. Engine ignition in vacuum conditions
        (1) First successful ignition of lunar module (LM) assent engine on lunar surface.
    c. At re-entry
        (1) astronaut suffers g force from back to chest
        (2) by restraining head and feet and providing harness for the body, astronaut's tolerance could be about 3 g for 8 min. and 2 g for 35 min.
3. Radiation

Film, "Space Medicine"

    a. Cosmic rays
    b. Gamma rays
    c. Ultra-violet rays
    d. X-rays
4. Noise and vibration
    a. Acoustic noise from rockets - will decrease with increase in speed.
    b. Aerodynamic noise
        (1) sound of turbulent air passing over and around space vehicle
        (2) will decrease in the thinner atmosphere as vehicle reaches higher altitude

5. Thermal effects
    a. Heat problems of exit and re-entry into earth's atmosphere
    b. Man can perform and function 10 min. at 300° without clothes
    c. Man can perform and function at 240° for 15 min. in flight suit
    d. Can perform indefinite time with protective clothing
    e. Heating from sun - 150°F on walls, sun side
    f. -290° with frost on walls, dark side
6. Microbiology
    a. Virus, molds, bacteria develop in spacecraft despite sterilization of capsule
    b. Microbes do not "settle out" in weightless state
    c. Microbes grow well in space; dark, damp warm
    d. Cabin at 75° and 40% relative humidity
    e. Body heat and heat from electrical equipment
    f. Reaction of bacteria on body

E. Basic elements of living in space
  1. Pressurized enclosure
      a. Space suit
      b. Space capsule
          (1) Gemini capsule allowed more room than Mercury; astronauts spent extended periods of time out of flight suits
          (2) Apollo capsule roomy, pressurized for comfort.

NASA Facts, "Living in Space."

Film, "Suited for Space"

  2. Heat
      a. Produced by electrical equipment
      b. Must be continually dissipated in space to maintain thermal balance of spacecraft
      c. Life support system processing uses energy in two forms - heat and electricity
  3. Water
      a. Of consumables carried, presents the most serious weight problem
      b. Allotment of 1½ gallon/day for

each astronaut
  c. From open glass, water would float out in a blob
  d. Necessary to force fluids into mouth
  e. Waste water purified for re-use
4. Atmospheric control
  a. Oxygen - amount depends on number in crew and length of mission
  b. Four-man crew in an orbiting space lab on a year-long mission would:
    (1) use about 2700 lbs. oxygen
    (2) exhale about 3300 lbs. CO_2
    (3) process of "regeneration" reduces basic amount of water and oxygen from 18,700 lbs. to 400 lbs.

NASA Film, "Regenerative Processes "

  c. Filtering system must clean air, remove odors
5. Food

NASA Film, "Food for Space Traveler "

  a. 11 lbs. of fuel needed to lift 1 lb. of weight off the earth; 212 lbs. of fuel needed to put 1 lb. into orbit
  b. 400 lbs. of food can be taken into space; will weigh only 54 lbs. after freeze dehydration

All but 2% of water is removed

  c. Space meals in individual sealed plastic containers
  d. To prepare food for eating:
    (1) water nozzle fits into valve on each food bag
    (2) nozzle delivers exact amount of water to reconsititute food
    (3) astronaut kneads bag to mix food and water
    (4) contents squeezed into mouth
  e. Biscuits, cookies, etc. are packaged in edible wrappers

Eat package and all

6. Personal hygiene problems
  a. Because of weightlessness, shaving, hair cutting, and clipping nails must be carefully controlled.
  b. Because of small quarters, other personal hygiene requirements may be difficult; e.g., bathing, brushing teeth, exercises.

VII. THE FACILITIES OF NASA

NASA Installations and "This is NASA"

- A. Headquarters, Washington, D.C. 20546
  - 1. Nerve center of whole program
  - 2. Policy, direction, and control
  - 3. Coordination and liaison
- B. Goddard Space Flight Center, Greenbelt, Maryland 20771
  - 1. Development of unmanned satellites
  - 2. Center for global communications, tracking systems
- C. Langley Research Center, Hampton, Virginia 23365
  - 1. Vehicle configuration
  - 2. Hypersonic and low speed studies

NASA Facts, "Langley Research Center "

- D. Wallops Station, Wallops Island, Virginia 23337
  - 1. Rocket-borne experiments
  - 2. Data acquisition
- E. John F. Kennedy Space Center, Florida 32931
  - 1. Manned and unmanned spacecraft launches
  - 2. Includes complete planning, designing, development and utilization of launching facilities
- F. Manned Spacecraft Center, Houston, Texas 77001
  - 1. Central test location for all manned spacecraft systems
  - 2. Astronaut selection and training
  - 3. Mission control
- G. Lewis Research Center, Cleveland, Ohio 44135
  - 1. Propulsion and space power generation
  - 2. Plum Brook Station, Sandusky, Ohio, with facilities for propulsion R&D is operated as an arm of Lewis
- H. George C. Marshall Space Flight Center, Huntsville, Alabama 35812
  - 1. Design and development of launch vehicles essential to Apollo and other major space missions
  - 2. Studies rendezvous operations, launch systems

3. Michoud Operations, Michoud, Louisiana 70129 manufacturers Saturn and other large launch vehicle stages
4. The Mississippi Test Facility, 50 miles east of New Orleans, is a facility for static tests of launch vehicles

I. Ames Research Center, Moffett Field, California 94035
   1. Laboratory and flight research in unmanned space flight and aeronautics
   2. Physics, materials, guidance and control, chemistry, life sciences, SST, V/STOL aircraft

J. Electronics Research Center, Cambridge, Massachusetts 02142
   1. R&D in electronics for application in space and aeronautics
   2. Organizes, sponsors and conducts programs in navigation, communications, data processing, and all electronic fields

K. Flight Research Center, Edwards, California 93523
   1. Manned flight within and outside the atmosphere
   2. Major programs include the X-15, B-70, paraglider, lifting body

L. Jet Propulsion Laboratory, Pasadena, California 91103
   1. Operated under contract to NASA by California Institute of Technology
   2. Development of spacecraft for manned and unmanned lunar and planetary exploration
   3. Worldwide deep space tracking

M. Nuclear Rocket Development Station, Jackass Flats, Nevada 89023
   1. Managed by the Space Nuclear Propulsion Office, a joint operation of NASA and the AEC
   2. Experiments, development, and testing for reactor technology and the nuclear engine and rocket stage for the nuclear rocket

N. Pacific Launch Operations, Lompoc, California 93438
   1. Administrative, logistic, and technical support for NASA at Western Test Range
   2. Missile and space launches

O. Pasadena Office, Pasadena, California 91103
   1. Branch of NASA Headquarters
   2. Serves all operational interests of NASA in the Western states
   3. Contract Negotiation
   4. Information source

VIII. CAREER OPPORTUNITIES

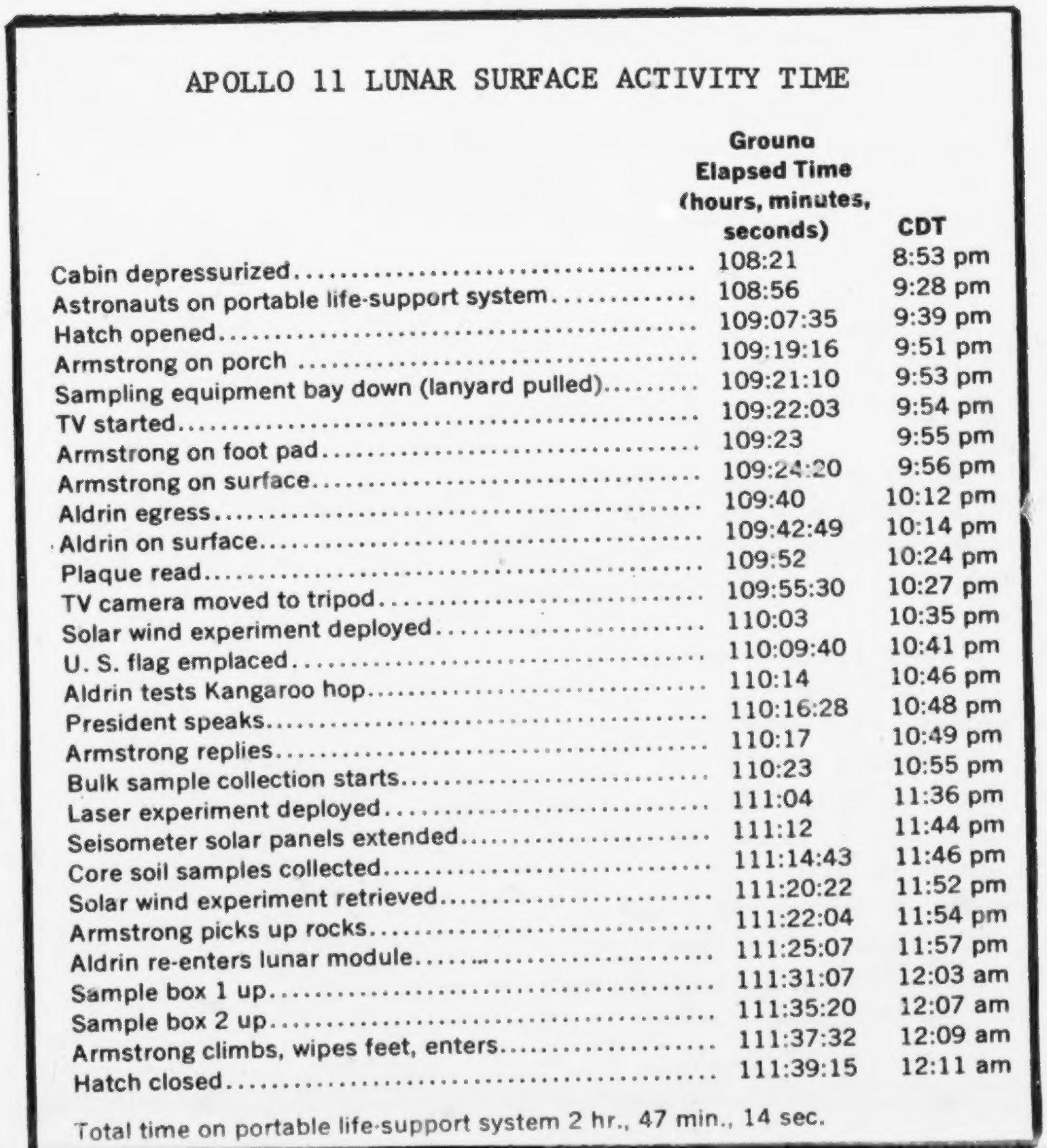
A. Professional opportunities in all branches of the sciences, mathematics, technologies

NASA: "Educational Guidance in the Space Age" and "Seven Steps to A Career in Space Science and Technology"

B. Semi-professional opportunities for technicians, managers, etc.

"Seven Steps to A Career in Space Science and Technology"

- -



APOLLO 11 LUNAR SURFACE ACTIVITY TIME

	Ground Elapsed Time (hours, minutes, seconds)	CDT
Cabin depressurized	108:21	8:53 pm
Astronauts on portable life-support system	108:56	9:28 pm
Hatch opened	109:07:35	9:39 pm
Armstrong on porch	109:19:16	9:51 pm
Sampling equipment bay down (lanyard pulled)	109:21:10	9:53 pm
TV started	109:22:03	9:54 pm
Armstrong on foot pad	109:23	9:55 pm
Armstrong on surface	109:24:20	9:56 pm
Aldrin egress	109:40	10:12 pm
Aldrin on surface	109:42:49	10:14 pm
Plaque read	109:52	10:24 pm
TV camera moved to tripod	109:55:30	10:27 pm
Solar wind experiment deployed	110:03	10:35 pm
U. S. flag emplaced	110:09:40	10:41 pm
Aldrin tests Kangaroo hop	110:14	10:46 pm
President speaks	110:16:28	10:48 pm
Armstrong replies	110:17	10:49 pm
Bulk sample collection starts	110:23	10:55 pm
Laser experiment deployed	111:04	11:36 pm
Seismometer solar panels extended	111:12	11:44 pm
Core soil samples collected	111:14:43	11:46 pm
Solar wind experiment retrieved	111:20:22	11:52 pm
Armstrong picks up rocks	111:22:04	11:54 pm
Aldrin re-enters lunar module	111:25:07	11:57 pm
Sample box 1 up	111:31:07	12:03 am
Sample box 2 up	111:35:20	12:07 am
Armstrong climbs, wipes feet, enters	111:37:32	12:09 am
Hatch closed	111:39:15	12:11 am

Total time on portable life-support system 2 hr., 47 min., 14 sec.

Permission was granted by Aviation Week & Space Technology to reprint this schedule from their July 28,1969, issue.

DEMONSTRATION #1

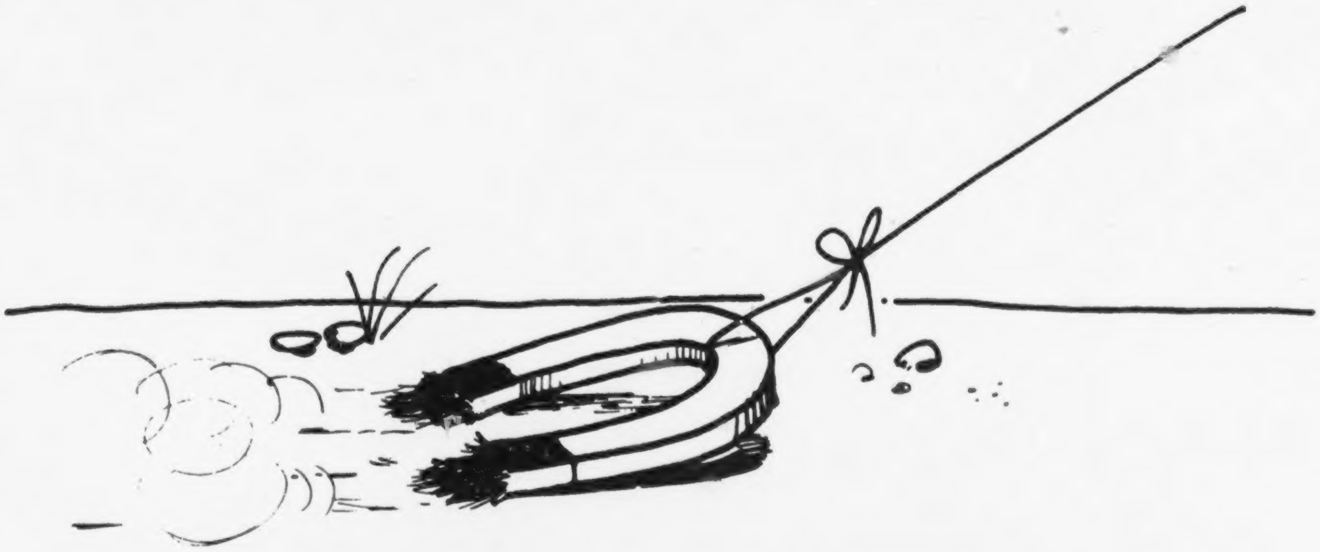
SUBJECT MAN IN SPACE

TOPIC "Space Hazards - Micrometeoroids"

CONCEPT Meteoric material in outer space

MATERIALS
String (3' to 4')
Strong "U" shaped magnet
Microscope (appox. 40-100x)

PROCEDURE
1. Attach string to magnet.
2. Have student drag magnet across lawn or field--allowing the magnet to collect any material that might be attracted to it.
3. Examine material collected--about 5% to 10% will be meteoric.
4. Observe some of the particles under a microscope. Note the kinds of structure. Identify some of the kinds of particles collected.



RELATED QUESTIONS AND INVESTIGATIONS
1. Investigate how we might identify particles from outer space? What scientific tools could be used for identification purposes?
2. Why would you not drag magnet along a street curb?

SUBJECT ROCKET VEHICLES

TOPIC Construction of an Action-Reaction Engine

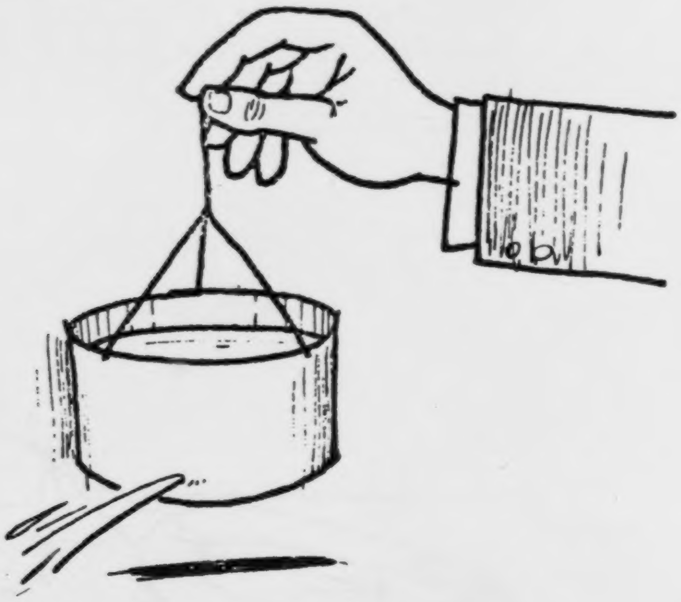
CONCEPT The rocket's basic operation is based on Newton's Third Law of Motion: "For every action there is an equal and opposite reaction."

MATERIALS

Water	Coffee Can
Cord	Hammer and Small nails

PROCEDURE

1. Punch a small hole in side of coffee can at bottom. Bend nail to side so water will pour out hole at angle. Then remove nail.
2. Fill can with water and observe movement of can as water spurts from opening.



RELATED QUESTIONS AND INVESTIGATIONS

1. Ask students how Newton's Third Law applies to this investigation?
2. Relate the results of this investigation to "turning" a satellite by utilizing a liquid or gas (propellant)?
3. Problem: How can you modify the apparatus to involve steam as the propellant?

DEMONSTRATION #3

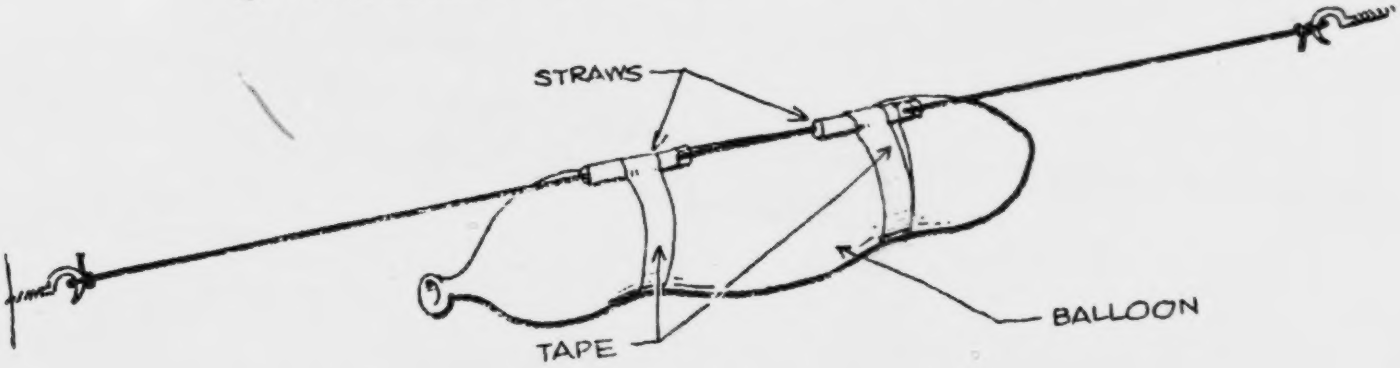
SUBJECT ROCKET VEHICLES

TOPIC Construction of an Action-Reaction Engine

CONCEPT The rocket's basic operation is based on Newton's Third Law of Motion: "For every action there is an equal and opposite reaction."

MATERIALS
- Nylon fish line
- Plastic straw
- Long balloon
- Tape

PROCEDURE
1. Fasten a fish line between two points in the classroom.
2. Hold the nozzle of the balloon to prevent air from escaping. Inflate the balloon and tape it to the straw as illustrated.
3. String the fish line through the straw while holding the nozzle of the balloon.
4. Now release the balloon nozzle and observe what happens.



RELATED QUESTIONS AND INVESTIGATIONS
1. Why does the balloon move?
2. How do you suppose this same balloon might perform in a complete vacuum?
3. What would happen to the range of the balloon if the string had a steeper incline? Why, then, do we launch rockets vertically, and then arc them over into horizontal flight? (Consider air friction and speed).

DEMONSTRATION #4

SUBJECT ROCKET VEHICLES

TOPIC Construction of Action-Reaction Engines

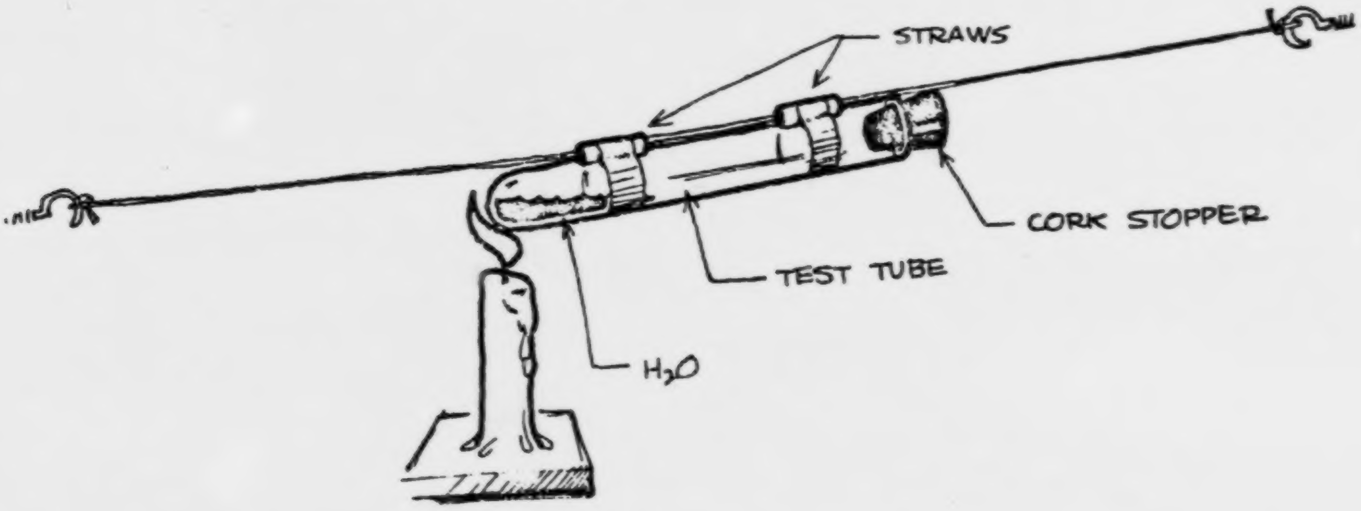
CONCEPT The rocket's basic operation is based on Newton's Third Law of Motion: "For every action there is an equal and opposite reaction."

MATERIALS

Small test tube with cork (pyrex test tube from Science Lab)
H_2O
Candle
Thread
Ring Stand
Vaseline

PROCEDURE

1. Set up apparatus as illustrated.
2. Lubricate cork stopper with vaseline.
3. Place a tablespoon of H_2O in the bottle. Position test tube over candle flame and note the reaction of the test tube as the cork pops out.



RELATED QUESTIONS AND INVESTIGATIONS

1. Problem: How does this investigations illustrate Newton's Third Law?
2. Discuss the similarity between this propulsion system and a rocket engine.

DEMONSTRATION #5

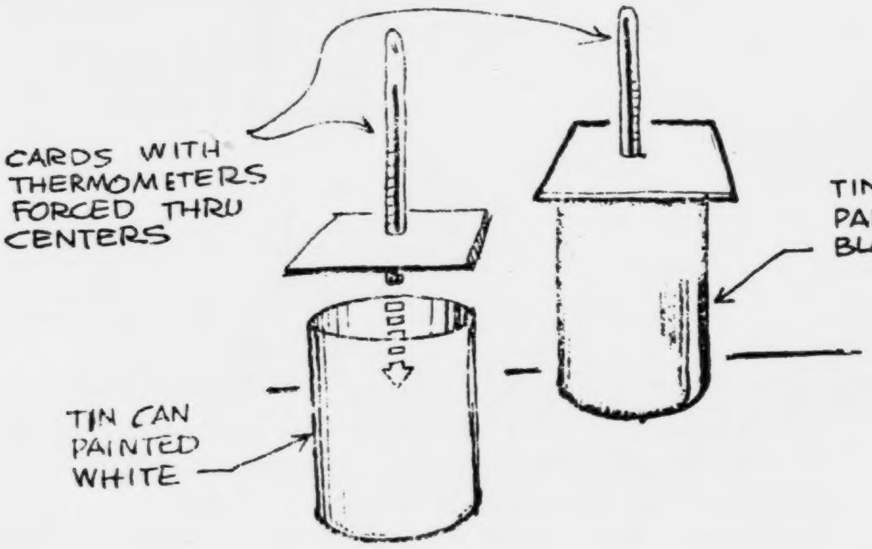
SUBJECT ROCKET VEHICLES

TOPIC Temperature Control

CONCEPT The amount of radiant energy different materials absorb or reflect varies according to their surface color.

MATERIALS
Tin Cans
Lab Thermometers (2)
Light cardboard
Heat Lamp
Candles (2)
Rubber bands
Paint (black and white spray)

PROCEDURE
1. Paint 1 can white and the other black. Allow them to dry.
2. Suspend thermometers in cans, through holes in cardboard; bulb must not touch can.
3. Direct heat lamps at cans so the rays shine directly on the cans but not on the thermometers.
4. Record the different temperatures.
5. Touch the cans and note the difference in temperatures.
6. After a brief cooling-off period, light two candles and attach to sides of cans.
7. Direct heat lamp at the cans again.
8. Observe what happens to the candles after a short period of time.



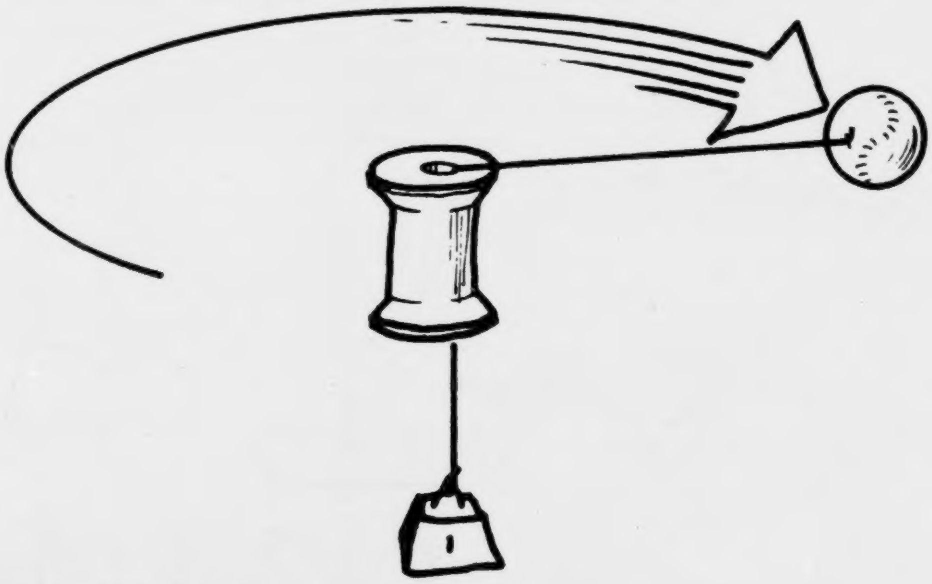
RELATED QUESTIONS AND ANSWERS
1. If intermediate colors (yellow, pink, red, etc.) instead of white were used, how do you suppose the temperatures would be affected?
2. What colors should be used for propellant tanks?
3. Why doesn't Titan II have varying colors as does Saturn I?
4. What other reasons can you think of for using other color patterns?

DEMONSTRATION #6

SUBJECT	SATELLITES AND SPACECRAFT
TOPIC	"Orbit Velocity"
CONCEPT	Many forces act upon a spacecraft as it orbits the earth.
MATERIALS	One 3' piece of heavy cord Sponge baseball Coat hanger 1 lb. weight Metal sleeve or wooden spool Wire cutters

PROCEDURE

1. Attach hanger to ball. Run a weighted cord through the sleeve and attach to the eye hook.
2. Swing ball around until velocity of the ball counterbalances the weight.
3. Observe what happens at varying velocities.
4. Determine and discuss what forces work on a satellite and what keeps it in orbit.



RELATED QUESTIONS AND INVESTIGATIONS

1. Ask students: "If you cut the string, what would happen to the ball? What would this represent?"
2. What do the varying velocities show?
3. Problem: How would you show an elliptical orbit using this device?
4. Discuss the forces acting upon the orbiting object.

DEMONSTRATION #7

SUBJECT MAN IN SPACE

TOPIC "Biological Sensors"

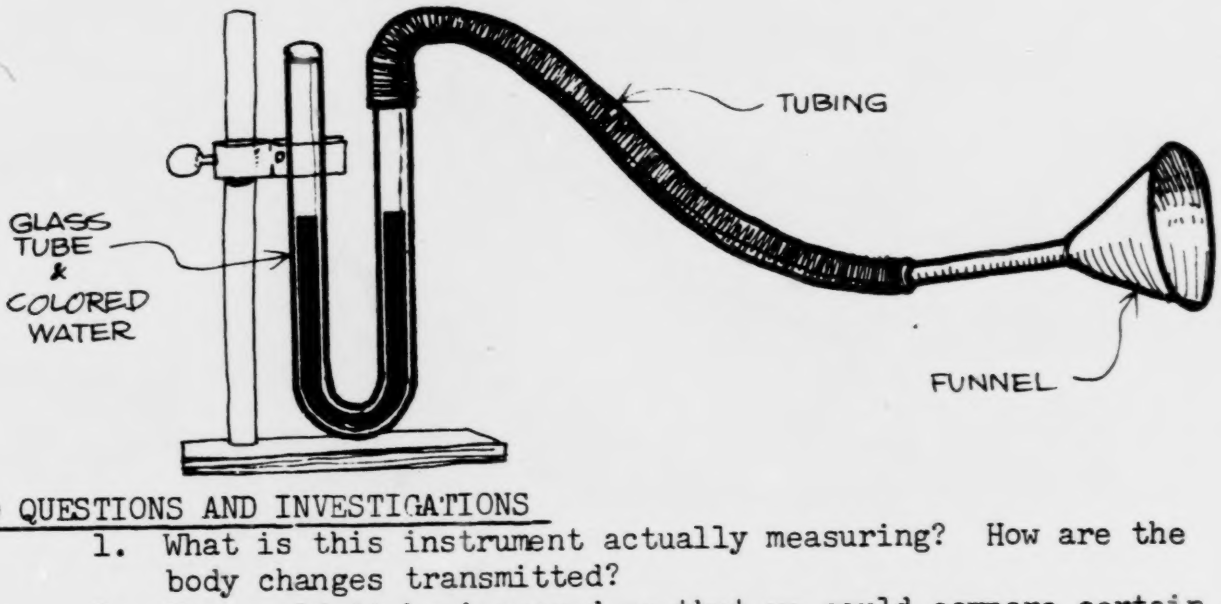
CONCEPT Certain body activities of animals and man can be monitored and measured as they orbit the earth in their spacecraft.

MATERIALS

Water, colored with ink
U-shaped tube or
2 glass tubes with rubber tubing connection
Ring stand or wooden holder
Funnel
Rubber or plastic tubing

PROCEDURE

1. Half fill a manometer tube with water (a u-shaped tube, see diagram, or two pieces of glass tubing and an attached short length of rubber tubing.
2. Attach a length of rubber or plastic tubing with a two inch funnel on the end.
3. Press the funnel over the carotid artery in your neck beside the windpipe, or over your heart on the left side of the chest.
4. Observe the action of the liquid in the tube.



RELATED QUESTIONS AND INVESTIGATIONS

1. What is this instrument actually measuring? How are the body changes transmitted?
2. How could it be improved so that we could compare certain physiological factors of one animal with another?
3. If the funnel was being used in a manned spacecraft, how could we transmit the change in liquid level back to the scientists on earth?
4. Discuss which body changes of astronauts should be transmitted back to earth-based scientists and possible devices that could be used in accomplishing this.

RESOURCES

Reference Books:

American Heritage, *History of Flight*. New York: American Heritage Publishing Co., Inc., 1962.

Bernardo, James V., *Aviation and Space in the Modern World*. New York: E. P. Dutton & Company, 1968.

Bryan, Leslie, *et al*., *Fundamentals of Aviation and Space Technology*. Institute of Aviation, University of Illinois, 1968.

Burns, N.M. and R. Chambers, *Unusual Environments and Human Behavior*. Glen Cove, N.Y.: Freepress of Glen Cove, 1963.

Earth and Space Science, A Guide for Secondary Teachers. Commonwealth of Pennsylvania, Dept. of Public Instruction, 1963. $1.00

Gantz, Kenneth F., *Man in Space*. New York: Duell, Sloan & Pearce, 1959.

Gerathewohl, Siegfried, *Principles of Bioastronautics*. Englewood, N.J.: Prentice-Hall, Inc., 1963.

Glasstone, Samuel I., *Source Book of the Space Sciences*. Princeton: D. Van Nostrand Co., Inc., 1965.

Hunter, Maxwell W., *Thrust Into Space*. New York: Holt, Rinehart and Winston, 1966.

McClements, F.A., *Anvil of the Gods*. Philadelphia: Lippinot Co., 1964.

NASA, *NASA Installations: Focus for Achievement*, (0-716-669). Washington,D.C., GPO, 1963.

NASA, *The Measurement of Blood Pressure in the Human Body*, (SP-5006), Washington, D.C.: GPO.

NASA, *Space Medicine in Project Mercury*, (SP-4003). Washington, D.C.:GPO.

NASA, *Space: The New Frontier*, (0-223-626). Washington: GPO, 1967. 75¢

Perry, Robert L.,"*The Antecedents of the X-1*," The RAND Corporation, P-3154, June, 1965.

Simons, David G., *Man High*. New York: Doubleday & Company, Inc., 1960.

Stillwell, W.H., *X-15: Research Results*, (SP-60). Washington: GPO, 1965.$1.00.

Swenson, Lloyd S., James M. Grimwood, and Charles C. Alexander, *This New Ocean: A History of Project Mercury*. Washington: NASA, 1966. NASA SP-4201 (GPO).

"Ten Steps Into Space," Monograph 6, *Journal of the Franklin Institute*. Philadelphia, Pennsylvania.

Thomas, Shirley, *Satellite Tracking Facilities*. New York: Holt, Rinehart, and Winston, 1966.

Von Braun, Wernher and Frederick I. Ordway,III, *History of Rocketry and Space Travel*. New York: Thomas J. Crowell Company., 1966.

Walters, Helen B., Hermann Oberth: *Father of Space Travel*.New York: Macmillan Company., 1962.

Yale, "Search for Extraterrestrial Life." Yale Reports, Woodridge Hall, Yale University, New Haven, Connecticut 06520

MAN IN SPACE

Reference Books and Information:

Aerospace Bibliography (Fourth Edition), Government Printing Office.1968. 40¢

Above and Beyond: The Encyclopedia of Aviation and Space Sciences. Chicago: New Horizons Publishers, Inc., 1968.

Ahrendt, Myrl H., The Mathematics of Space Exploration. New York: Holt, Rinehart, and Winston, 1966.

Caidin, Martin, Wings Into Space. New York: Holt, Rinehart, and Winston, 1966.

Coombs, Charles, Gateway to Space. Toronto: McLeod, Ltd., 1960.

Dreyer, John L. E., A History of Astronomy from Thales to Kepler, 2nd Edition. New York: Dover, 1953.

Emme, Eugene M., Aeronautics and Astronautics: An American Chronology of Science and Technology in the Exploration of Space, 1915-1960.Washington: NASA, 1961.

Emme, Eugene M., History of Space Flight. New York: Holt, Rinehart, and Winston, 1965.

Exploring Space: A Guide For Teachers. World Book Encyclopedia, 1967.

Gray, G. W., Frontiers of Flight. New York: Alfred A. Kropf, 1948

Hynek, J. Allen and Norman D. Anderson, Challenge of the Universe. New York: Scholastic Book Services, 1962.

Kaiser, Hans K., Rockets and Spaceflight, (translation by Alex Helm). New York: Pitman, 1962.

Levitt, Israel M., A Space Travelers' Guide to Mars. New York: Holt, Rinehart, and Winston, 1956.

Ley, Wiley, Conquest of Space. New York: Knickerbocker Press, 1951.

Ley, Wiley, Rockets, Missles, and Space Travel, Revised Edition. New York: Viking Press, 1961.

National Aeronautics & Space Administration -- Single copies of the following publications are available free from one of the NASA Centers (See pages 233 and 234). Larger quantities are available at cost from the U.S.Government Printing Office, Washington, D.C. 20402. Request price list from the Supt. of Documents. Educational Publications (EP Service):

EP-20	Educational Guidance in the Space Age
EP-22	This is NASA
EP-33	Seven Steps to a Career in Space Science and Technology
EP-34	NASA Astronauts
EP-39	Report from Mars
EP-48	Aerospace Bibliography:4th Ed. (Books,Pamphlets, Audio visuals)

- -

America in Space: The First Decade Series:

EP-51	Space, Physics and Astronomy
EP-52	Exploring the Moon and Planets
EP-53	Putting Satellites to Work
EP-54	NASA Spacecraft
EP-55	Spacecraft Trucking
EP-56	Linking Man and Spacecraft
EP-57	Man in Space
EP-72	Log of Apollo 11

- -

NASA Facts (NF series)

NF-8	Launch Vehicles
NF-9	Manned Space Flight (Mercury-Gemini)
NF-17	Project Relay
NF-20	U.S.Launch Vehicles for Peaceful Exploration of Space
NF-21	V/STOL Aircrart
NF-23	Manned Space Flight (Apollo).

NASA Facts (NF series) continued:
NF-25 Explorer XXIX (The Geodetic Explorer)
NF-26 A Report from Mariner IV.
NF-27 Living in Space
NF-29 Orbiting Solar Observatory
NF-30 Gemini Pictorial
NF-31 Pioneer
NF-32 Lunar Orbiter
NF-33 Saturn V
NF-34 Lifting Bodies
NF-36 Simulators
NF-37 Space Navigation
NF-38 Electric Power in Space
NF-39 Mariner Spacecraft
NF-40 Journey to the Moon
NF-41 Food for Space Flight

0-7 NASA - Langley Research Center
S-6 Solar Cells
S-7 Orbits and Revolutions of a Spacecraft

National Aerospace Education Council, Sources of Free and Inexpensive Pictures, Pamphlets, and Packets for Aviation and Space Education. Write NAEC, 806 15th Street, N.W., Washington, D.C. 20005. 50¢

Perry, Robert L., "The Antecedents of the X-1," The RAND Corporation, P-3154, June, 1965.

Periodicals:

Kirschner, Edwin J., Mobility for Moon Exploration, Washington, D.C.: Defense Transportation Journal - Sept/Oct. 1969 issue.

*NASA Films:

"Apollo 9: The Space Duet of Spider and Gumdrop.(HQ-189).1969 Color-28:30 min.
"Apollo 10: Green Light for Lunar Landing"(HQ-190).1969,Color,28½min.
"Assignment: Shoot the Moon," (HQ-167).1967,Color, 28 min.
"The Biosatellite Program - Between the Atom and the Star,"(HQ-107). 1965, Cilor, 28 min.
"Eagle Has Landed -- The Flight of Apollo 11," Color,Sound,1969 (HQ-194), 28:30 min.
"Electric Power Generation in Space," (HQ-155). 1967,Color,26½ min.
"Food for Space Travelers," (HQk-SR3). 1966,B/W, 29 min.
"Landing on the Moon" (HQk-SR2),1966, B/W, 28min.
"Living in Space," (HQ 131 series).
  Part I, "A Case for Regeneration," (HQ-131-A).1967,Color,12 min
  Part II, "Regenerative Processes," (HQ-131-B).1967,Color,20min.
  Part III, "A Technology for Spacecraft Design," (HQ-131-C).1967, Color, 20 min.
"Power for the Moonship," (HQk-SR4). 1966, B/W, 29 min. Fuel cells.
"Returns From Space," (HQa-156). 1966,Color, 27 min. Useful benefits from space research and development.
"Research Project X-15," (HQ-79). 1966,Color, 27 min.
"Returning from the Moon," (HQk-SR9). 1966, B/W, 28 min.
"Room at the Top," (HQk-SR7). 1966, B/W, 28 min. Command Module of the Saturn - Apollo.

MAN IN SPACE

"Space Medicine," (HQk-SR8). 1962, B/W, 29 min.

"Suited For Space," (HQk-SR5). 1966, B/W, 28:30. History of space suits.

"Universe," (HQa-91). 1960, B/W, 28 min. Animated look at the solar system, Moon, Mars, Venus, Mercury, Earth, Saturn and the Milky Way and galaxies beyond.

"A View of the Sky," (HQ-163). 1967, Color, 28 min. Historical theories of the universe from Copernicus through Einstein.

*Note: This is only a partial list of NASA films available. Request a current NASA film list for the complete listing. Refer to List of Film Producers and Distributors in back of Course of Study for addresses. (See pages 233 and 234.

Other Aids:

National Aeronautics and Space Administration: Available from NASA Centers (See pages 233 and 234 for addresses).

Filmstrips:

"Don't Build That Rocket Alone!" (FS-1). 1965, Color, 64 frames with record and script.

"Electric Propulsion," (FS-4). 1965, Color, 110 frames with script.

"Geology from Space," (FS-3). 1967, Color, 24 frames with record and script.

"In Sight of the Giant Steps," (FS-4). 1967, Color, 40 frames with record and teacher's guide. History of space exploration.

"Meteorology from Space," (FS-5). 1967, Color, 22 frames with record and script.

"Project Apollo - Manned Flight to the Moon," (FS-6). 1963, Color, 100 frames with script.

"Reach for the Moon and Touch a Star," (FS-7). 1967, Color, 40 frames with record and teacher's guide. History of space exploration.

"Space Navigation," (FS-8). 1967, Color, 69 frames with script.

Spacemobile Lecture - Demonstration Program. The Spacemobile is a unit composed of a lecturer with science teaching background, equipment for space science demonstrations, and 20 to 25 models of NASA spacecraft and launch vehicles transported in a panel truck.

National Aerospace Education Council, 806 15th Street, N.W., Room 310, Washington, D. C. 20005:

"Project Apollo." Chart 44" x 25" with 27 captioned drawings, photographs, and diagrams tracing, step by step, how astronauts will land on the moon, what they will do on the moon, and how they will return to earth. $1.00

"Robert H. Goddard Portfolio No. 1." Ten selected black and white captioned pictures from the life and work of the "father" of modern rocketry, 8½" x 11". $1.00 per set.

"NAEC, Sources of Free and Inexpensive Pictures, Pamphlets, and Packets for Aviation and Space Education."50¢

"U. S. Aircraft, Missiles and Spacecraft"- NAEC. Annual - $3.00

INTRODUCTION

Because he was never able to attain it, earliest man believed the art of flight was associated with the supernatural. Today, a high school junior can fly his terrestrial bound parents at 120 miles per hour and more. The art of flight can be achieved by anyone who cares to do so.

Too often we are prone to look upon man's accomplishments with a "so what else is new" attitude. We are indifferent to the efforts of our predecessors. They hurled themselves against the stone walls of ignorance and eventually climbed, step by step, up the stairway of knowledge. The student, old or young, should be aware of this well established fact: We build upon the knowledge gained by our fathers. It is to them we owe the fact that we can enjoy flight with such ease today.

The skies have always challenged man and will continue to do so as long as he is given life upon this planet. Let us see what was in the mind of the early dreamers of flight and let us see what they accomplished. From their mistakes, others learned and progressed. Perhaps we can learn too.

TO THE TEACHER

No one text can suffice in offering all that is needed in a study of man's conquest of the air. However, the book FLIGHT; A Pictorial History of Aviation, comes as close as any to fulfilling the need. And, from this book, an outline of history of aviation through World War II was prepared.

The page number of each section is indicated and the page number of selected reading and photos in supplementary texts are also shown. Supplemental references, other aids, and films are listed under "Resources" at the end of this unit. A list of suggested topics for reports is also included.

UNIT OUTLINE

I. MYTHOLOGY AND RELIGION

- A. Daedulus and Icarus
- B. Pegasus
- C. Biblical Accounts of Flight
- D. Mercury
- E. The Magic Carpet
- F. The Early Use of Kites
- G. Superstitution

Misenhimer - History of Aviation Unit.
Flight, p. 10
American Heritage, pp. 10-12, 16-25, 34-36
Gibbs-Smith, *The Aeroplane*, Chapt. 1-3

II. BALLOONS AND GLIDERS

- A. The Montgolfier Brothers
  - 1. Paper "Balloon"
  - 2. Hydrogen Filled Balloons

Flight, pp. 10-29, 14
American Heritage, pp. 39-77, 40-42, 27-28, 63

- B. First Military Uses of the Balloon
  - 1. French Revolution
  - 2. Civil War
  - 3. Franco-Prussian War
  - 4. Sky-Cycle
  - 5. Santos-Dumont
  - 6. Zeppelin

Flight, pp. 22-24, 27, 53
American Heritage, pp. 44-45, 54-55, 64-65, 70-71, 77, 118, 120, 122, 124-125, 127, 135
Palmer, pp. 77-78, 17

- C. Heavier-Than-Air Craft
  - 1. Leonardo da Vinci
  - 2. John Montgomery
  - 3. Octave Chanute
  - 4. Otto Lilienthal
  - 5. Samuel Langley
  - 6. Orville and Wilbur Wright
    - a. Glider Experiments
    - b. Controls

Flight, pp. 13, 18, 28-29, 32
American Heritage, pp. 26-27, 78-86, 102-105, 112-115, 119
Palmer, p. 25

III. POWERED FLIGHT

- A. Wright Brothers
  - 1. December 17, 1903
  - 2. U.S. Signal Corps
- B. Glenn Curtis
  - 1. Wind-Wagon to "Redwing"
  - 2. Father of Naval Aviation
  - 3. Birth of the Carrier - Ely
- C. Bleriot - Channel Flight
- D. First International Meet - RHEIMS - 1909

Flight, pp. 32, 40-43, 46, 48-49, 54, 62, 63, 67, 71-75 97
American Heritage, pp./124-125, 128-131, 138-139, 148, 156-157, 164, 179, 192, 395
Caidin, pp. 2-6
Palmer, pp. 63-64, 68
Naval Aviation in Review, pp. 14-15, 259-261
Gibbs-Smith, The Aeroplane, Chapt. 9-11

E. Sky Cruisers - Airships

F. First Air Show in America - Dominguez Field, Los Angeles, 1910.
G. Valiant Efforts and Multiplanes

H. "Greatest of Them All" - Lincoln Beachey

I. Glenn L. Martin

J. Sikorsky's "Grand"

K. Early Helicopter Development

L. The First Scheduled American Airline - Tampa to St. Petersburg 1914.
IV. FIRST WORLD WAR

A. Use of Aircraft at Beginning of War

Flight, pp. 79-91
American Heritage, pp. 158-195
Naval Aviation in Review, pp. 17-18.
Gibbs-Smith, The Aeroplane, Chapt. 12.

B. Fokker adapts the Synchronized Gun

C. Famous Planes
  1. German
    a. Rumpler Taube
    b. Fokker D VII
    c. Fokker DR-I
    d. Fokker D VIII
    e. Junkers
    f. Gotha
  2. Allied
    a. Spad
    b. Nieuport
    c. SE-5
    d. DH-4

D. Military Airships and Balloons

E. Aces of World War I
  1. German
    a. Von Richtofen
    b. Udet
    c. Goering
  2. Allies
    a. Fonck
    b. Gynemen
    c. Rickenbacker
    d. Lufbery
    e. Nungesser
    f. Luke

V. THE COURAGEOUS TWENTIES

Gibbs-Smith, The Aeroplane, Chapt. 13.

A. Dramatic Flights
  1. NC-4
  2. Alcock and Brown
  3. Douglas World Cruisers
  4. Non-Stop Coast-to-Coast
  5. The Lone Eagle
  6. Chamberlin
  7. Byrd
  8. Maitland and Hegenberger
  9. Sir Charles Kingsford-Smith

Flight, pp. 93-114, 142
American Heritage, pp. 155, 196-239, 242-243, 250, 278-279
Caidin, pp. 26-57
Roseberry, pp. 21, 23, 47-48, 65-74, 84-85, 89-90, 91, 93-98, 163-164, 193-196
Naval Aviation in Review, pp. 226-232

B. Technical Pioneering
  1. Trophy Races
  2. Billy Mitchell
  3. Decline of Military Aviation
  4. Science Adds Safety
  5. Helicopter Rotor System

Flight, pp. 97, 99, 100, 110-111, 135
American Heritage, pp. 219, 226-227
Caidin, pp. 44-46, 48-51, 80-83
Roseberry, pp. 54-62
Naval Aviation in Review, pp. 262-263

C. Airships
  1. Shenandoah, Akron, and Macon
  2. R-34
  3. Graf Zeppelin
  4. Norge (semi-rigid)

Naval Aviation in Review, pp 241-257

VI. Commercial Aviation

Flight, pp. 119-127
American Heritage, pp. 266-267

A. Airlines
  1. Mergers of the Early 30's
  2. Army Flies the Mails
  3. China Clipper
  4. DO-X
  5. Douglas DC-3 vs. Boeing 247-D
  6. Death of the Airship

Flight, pp. 118-135, 121, 122, 126
American Heritage, pp. 268-269, 253, 272-273
Roseberry, pp. 357-362, 447-449

B. Outstanding Flights
  1. Trans-Ocean Flights
  2. Lockheed's Contribution
  3. "Winnie Mae"
  4. "Wrong Way" Corrigan
  5. Italo Balbo
  6. Howard Hughes
  7. Russia's Ant-25
  8. Amelia Earhart
  9. Jacqueline Cochran

Flight, pp. 128, 131-137, 163
American Heritage, pp. 250-253, 256-260, 274-275
Roseberry, pp. 182-183, 263-265, 267-269, 271-279, 330-332, 428-429, 465-468

VII. REHEARSAL WARS

Gibbs-Smith, The Aeroplane, Chapt. 14.

A. China

B. Ethiopia

C. Spain

D. Finland

VIII. WORLD WAR II

A. The Air Blitz
1. Stuka Dive Bomber
2. Use of the Luftwaffe

B. Battle of Britian
1. Hurricane
2. Spitfire
3. Messerchmitt 109

C. U.S. Expansion
1. The Arsenal of Democracy
2. Lend-Lease

Flight, pp. 141, 144, 146-150, 154, 156, 158-167
American Heritage, pp. 296-297, 300-304, 306-307, 310-311, 313-314, 318-319, 344
Caidin, pp. 100-111
Roseberry, p. 490
Naval Aviation in Review, pp. 23-28, 153-156, 174-176, 223-225

D. "Flying Tigers"

Gibbs- Smith, The Aeroplane, Chapt. 15

E. Pearl Harbor

F. U.S. Operations in Europe

G. U.S. Operations in the Pacific

H. U.S. Production of Aircraft

I. U.S. Military Aircraft of W.W. II
1. BT-13
2. AT-6
3. AT-17
4. P-40
5. P-38
6. P-47
7. P-51
8. P-80
9. B-17
10. B-26
11. B-25
12. B-24
13. B-29
14. F4F
15. F6F
16. H-4
17. PT-13, 14,17
18. PT-22
19. PT-19

For references for these aircraft, see Aircraft Profile Publications, National Aerospace Education Council.

J. Principal Axis Aircraft
1. Focke-Wolf 190
2. Messerchmitt 109
3. Stuka Dive Bomber - Junkers Ju 87
4. Junker Tri-motor Cargo-Ju 52
5. Me 262
6. Mitsubishi Zero

RESOURCES

Textbooks:

American Heritage, History of Flight. New York: American Heritage Publishing Company, Inc., 1962.
Caidin, Martin, Golden Wings. New York: Random House, Inc., 1960.
Flight; A Pictorial History of Aviation, by the editors of "YEAR." Forge Village, Mass., Murray Printing Company, 1961.
Gibbs - Smith, C.H., The Aeroplane: An Historical Survey of Its Origins and Development. London: Her Majesty's Stationery Office (H.M.S.O.), 1960. This is currently the definitive work in the field.
Naval Aviation in Review, Issued by the Chief of Naval Operations, U.S.Navy. NAVAER 00-80T-58,1958.
Palmer, Henry R., Jr., This Was Air Travel. Seattle, Washington: Superior Publishing Company, 1960.
Roseberry, C.R., The Challenging Skies, Garden City, New York: Doubleday and Company, 1966.

Reference Books and Information:

Aerospace Industries Assn., The Aircraft Year Book for 1949. Fred Hamlin, Arthur Clawson, William Key, and Eleanor Thayer (eds.), Washington, D.C.: Lincoln Press, Inc., 1949.
Allen, Richard Sanders, Revolution in the Sky. Brattleboro, Vermont: The Stephen Green Press, 1964.
Bernardo, James V., Aviation and Space in the Modern World. New York: E.P. Dutton & Co., 1968
Gibbs-Smith, C.H., The Invention of the Aeroplane 1799-1909. New York: Taplinger Publishing Company, 1966.
Gibbs-Smith, C.H., A Directory and Nomenclature of the First Aeroplane, 1809 to 1909. London: H.M.S.O., 1960.
Misenhimer, Ted G., Aeroscience. Culver City, California: Aero Products Research, Inc., 1969.
National Aerospace Education Council, Aviation Education Bibliography, Washington, D. C. 20005
Nielson, Dale, Saga of the U.S.Air Mail Service. P.O. Box 8-104, International Airport, San Francisco 28, California.
Smith, Henry L., The History of Commercial Aviation in the United States. New York: Alfred A. Knopf, Inc., 1942.
"Smithsonian Annals of Flight," Smithsonian Institution, National Air and Space Museum. Washington, D.C.: U.S. Government Printing Office.
Stever, H. Guyford, James J. Haggerty, and the editors of "Life", Flight. New York: Time Incorporated, 1965.
Wilson, G. Lloyd and Leslie A. Bryan, Air Transportation. New York: Prentice-Hall, Inc., 1949.

HISTORY OF AVIATION

Films:

*Federal Aviation Administration
  "Aeronautical Oddities," (WF-00-36). 1951, B/W, 21 min. Early attempts at flight.
  "We Saw It Happen," (SFP-355). 1954, 2 reels, B/W, 58 min. Summary of aviation development from the first flights of the Wright Brothers to the present.
*Goodyear Tire & Rubber Company
  "Airships," 16 min. Construction, history, and flight of lighter-than-air-craft.
*McGraw-Hill Films
  "The Day Men Flew," Code 632499. B/W, 17 min., $100.
  "The First Flight of the Wright Brothers," Code 400430. CBS "You Are There" series. B/W, 27 min., $150.
  "Air Age," Code 658127. Wright Brothers to man carrying rockets. B/W, 26 min., $125
  "The Early Days," Code 618004. Early attempts at flight through World War I. B/W, 27 min., $125.
  "History and Development of the Rocket," Code 683009. B/W, 16 min., $95.
*National Aeronautics and Space Administration, "The Dream That Wouldn't Die," (HQk 125). Early experiments of Dr. Robert Goddard. 1965,B/W, 27min.
*U.S.Air Force, "Road to the Stars," (SFP 595). Traces the history of the rocket and its development. Color, 1958, 27 min.
*U.S.Navy, "The Story of Naval Aviation," (MN 9633). Development of naval aviation from 1911 to present. 1961, 28 min.

*See pages 233, 234 and 235 for addresses.

Other Aids:

"A Half-Century of Progress in Scheduled Air Transportation," Air Transport Association of America, 1000 Connecticut Ave., N.W., Washington, D.C. 20036.
American Aviation Historical Society, Journal (published quarterly), P.O. Box 45-435, Los Angeles, California 90045.
"Flight Then," Air World Education, Instructor Series II. Trans World Airlines, 380 Madison Ave., New York 17, New York.
"A Chronology of American Aerospace Events," Department of the Air Force. Washington, D. C. AFP 190-2-2, 1961.

Note: "History of Aviation" (KN-10759): As of press time (September 1969), the U.S. Navy was producing a series of 28½-minute video tape segments on the history of aviation. Mr. Paul Garber, Historian Emeritus and Ramsey Research Associate of the National Air and Space Museum of the Smithsonian Institution, serves as lecturer. The series begins with early mythology and man's first thoughts of the theory of flight. The viewer is brought to present-day aviation through a progression of historical aeronautical accomplishments. It is planned to release this series in 16 mm film and video tape. For further information, contact: Special Assistant for Aviation Education, Federal Aviation Administration, Washington, D. C. 20590.

SUGGESTED BIOGRAPHIES AND TOPICS FOR REPORTS

Report Length, 250 to 500 words

1. Gen. Italo Balbo
2. Berlin Air Lift
3. Louis Bleriot
4. Adm. Richard E. Byrd
5. Sir George Cayley
6. Octave Chanute
7. Gen. Claire Chennault
8. Jacqueline Cochran
9. Douglas Corrigan
10. Glenn Curtis
11. Gen. Jimmy Doolittle
12. Santos Dumont
13. Amelia Earhart
14. Anthony Fokker
15. Rene Fonck
16. Dr. Robert Hutchings Goddard
17. Hermann Goering
18. Sir Charles Kingsford-Smith
19. Samuel Langley
20. Otto Lilienthal
21. Charles A. Lindbergh
22. Glenn Martin
23. Billy Mitchell
24. John Montgomery
25. Wiley Post and Harold Gatty
26. Eddie Rickenbacker
27. Ernst Udet
28. The V-1
29. The V-2
30. Dr. Wernher von Braun
31. Manfred von Richthofen
32. Sir Hubert Wilkins
33. Orville Wright
34. Wilbur Wright
35. Count Zeppelin

ECONOMIC FACTORS OF AVIATION AND SPACE

INTRODUCTION

No other mode of transportation has had such an impact on the economy and the individual as aviation. The economic and social changes that have occurred as a result of air transportation and aerospace developments have been truly significant.

The youth of today must have an awareness of the history, the regulation, the practical effect, and the importance to the future of aviation and space efforts. To be responsible citizens, young men and women must realize that various phases of this industry will touch their lives -- as taxpayers, voters, users of transportation, employees, and perhaps later as employers. Aviation is a recognized form of transportation through which much of our distribution processes operate -- distribution of population as well as of manufacturing and services; and space travel conceivably could be added to become a way of life. The student will also be interested in the economic impact of the aerospace industry. Not only is it our biggest employer, but it is adding to a wealth of technology in their own industry as well as applying much of that technology to solve problems in other fields, such as social and urban problems.

The economics of aviation is a course in itself. However, this unit presents a broad general outline of the economic importance of our air transport system, including how it was organized and how it is run. It is hoped that, given even an overview of the subject, the student will have a better appreciation of the importance of aviation and space in his own life and in the economy of his community and the nation.

TO THE TEACHER

Each of us is influenced directly or indirectly by aviation and space. We may be direct users of their services, or depend on them for products, by-products, education, employment, or recreation. The goals of this unit, therefore, are to help the student to become more aware of the following:

1. The importance of airports in our national transportation system;
2. The kinds of airports that exist today;
3. The types of airlines and how they are regulated;
4. The importance of general aviation;
5. The types of aviation and aerospace industries;
6. The career possibilities in both aviation and space.

Many local, state, and national problems can be incorporated as examples in teaching this unit. A visit to the local airport will help the student discover how air transport affects his daily life -- from incoming and outgoing air cargo (fruits, vegetables, other consumer goods) to the tax base of the airport itself and the transportation services and recreational facilities it offers to the community. The problems, too, should be discussed --zoning and noise abatement, for example.

Team teaching can be useful in presenting this unit as it touches on economics, sociology, politics, and law. Airport and air transport operators and the Federal Aviation Administration are glad to arrange field trips or to provide guest speakers. If more of the international aspects of air transportation are desired, representatives of foreign carriers can be contacted for guest lecturers, films and brochures.

Because there is no adequate text for this unit, more details are given in the unit outline than in some of the other units presented in this course outline. The sources used are listed at the end of the unit.

UNIT OUTLINE

I. Economic Impact of Aviation and space

Sources for Section I:
Above and Beyond, V.4, pp 670-672
Bryan, pp. 1 - 10
Bernardo, pp. 37-90

- A. Nearly two million persons are employed in the fields of aviation and space........more than in any other non-agrarian field.
- B. Millions of passengers fly on commercial airlines each year.
  1. More people are carried by air than by any other means of transportation.
  2. Air transportation has grown rapidly because:
     - a. Speed saves traveling time;
     - b. Costs are now attractive;
     - c. Air travel has become more comfortable than it was originally;
     - d. Airlines have better schedules and greater reliability than ever before -- often better than surface carriers; and
     - e. Its safety record is good.
- C. Commercial and military transport have affected international relations for U. S. and other nations.

Have students study timetables of international airlines to determine how long it takes to reach distant cities of the world.

- D. Both production and the distribution of goods and services are facilitated by the airplane.
  1. General use of commercial air transportation has changed warehousing, location of factories.
  2. Air transportation has helped to speed delivery of mail and express.

Arrange a panel discussion on how aviation contributes to our modern way of life.

- E. The use of business aircraft helps to reduce travel expenses, move experts and special parts rapidly in the case of breakdowns or special problems.
- F. Air taxis and helicopters help the passenger reach his destination quickly.

G. The use of private aircraft for business and pleasure is one of the fastest growing parts of our economy.

H. The use of helicopters in industry is solving special construction work and transport problems.

I. The use of the helicopter in traffic control and police patrols is increasing daily.

J. The use of aircraft in agriculture and health services reduces insect infestations, saves food crops, prevents sickness and epidemics, and provides air ambulance services.

II. Summary of Regulation and Administration of Aeronautics

References Section A:
Bernardo, pp. 92 - 96
Frederick, pp. 68-76,111-112
Whitnah, pp. 19-36,68
Burkhardt, Chapt. 1

"Federal Aviation Agency's Historical Fact Book". A Chronology 1926 - 1963.

A. Early legislation and regulations attempted to improve safety.
   1. Kelly Air Mail Act of 1925 provided for the transfer of air mail from the federal system to private air carriers.
   2. Air Commerce Act of 1926 charged Bureau of Air Commerce with licensing pilots, making flying safe, developing new air navigational facilities, mapping the airways, and furnishing flight information.
   3. The Watres Act of 1930 provided that the Postmaster General unify the air transportation industry.
   4. Air mail contracts were canceled early in 1934 because of alleged collusion between mail carriers and Post Office officials to defeat competitive bidding.
      a. The Army was ordered to take over flying the mail.
      b. Commercial air transport companies were reorganized, according to government requirements, to be able to present new bids.

5. Black-McKellar Act of 1934 made the air carriers responsible to three separate agencies.
   a. Post Office Dept. was to award contracts and determine schedules.
   b. Bureau of Air Commerce was to continue to operate the airways and license planes and pilots.
   c. Interstate Commerce Commission was to fix rates of air mail payments.
6. Civil Aeronautics Act of 1938 provided for complete federal control over every phase of interstate airline operations.
   a. Set up an administrative agency consisting of a 5-man Authority, a 3-man Safety Board, and an Administrator.
   b. Reorganization plans in 1940 placed the Administrator under the Secretary of Commerce, abolished the Safety Board, and changed the name of the 5-man Authority to the Civil Aeronautics Board. Investigation of accidents was thereafter handled by the CAB.
   c. CAB was to continue its roles of rulemaking, adjudication, and investigation independently.
   d. CAA Administrator was to foster civil aeronautics and commerce, establish civil airways, provide for air navigation facilities and the protection and regulation of air traffic on the airways. Also, recommend an adequate airport system.

"Federal Aviation Agency's Historical Fact Book". A Chronology 1926 - 1963.

7. Model Aviation Act of 1944 established a basis whereby state laws could be brought into conformity with federal regulations and with statutes of other states.
8. The Federal Aviation Act of 1958 replaced the Act of 1938 and repealed all conflicting legislation.

Burkhardt, Chapt.2

a. Continued the CAB as an independent government agency.	(See B, below.)
b. Created the Federal Aviation Agency, reporting directly to the President.	(See C, below.)
9. The National Aeronautics and Space Act of 1958 established the National Aeronautics and Space Administration.	(See D, below.)
B. The Civil Aeronautics Board	Bernardo, p.95
1. The CAB is charged with economic regulation of air transportation.	Frederick, pp. 112, 116-117 Whitnah, pp. 159-162 Above and Beyond, Vol.3, pp. 462-465
2. It is an independent federal agency comprised of 5 members appointed by the President with consent of the Senate for terms of 6 years.	
3. The major activities of the CAB are to:	CAB publications
a. Regulate fares and rates for the carriage of persons and property.	
b. Fix subsidy and service mail rates.	
c. Guarantee loans to certain classes of carriers for the purchase of flight equipment.	
d. Enforce the economic provisions of the law.	
e. Approve or disapprove mergers and intercarrier agreements.	
f. Regulate air carrier accounting practices.	
g. Maintain public records of tariffs, schedules, etc. filed by carriers.	
h. License domestic air routes, and, with Presidential approval, international air routes air carriers.	
i. Participate in the negotiation of air agreements between the United States and other governments.	

j. Assure protection of the public by:
    (1) Requiring the performance of safe and adequate air carrier service.
    (2) Eliminating rate discriminations and unfair competition or unfair and deceptive practices.

4. National Transportation Safety Board
    a. Newly formed in 1967 when Department of Transportation was created.
    b. Took over accident investigation functions from CAB.
    c. Investigate and determine probable causes of civil aircraft accidents.

C. The Federal Aviation Administration
1. The FAA became part of the Department of Transportation in 1967, and its name was changed from Agency to Administration.

Burkhardt, Chapt. 14
Dept. of Transportation signed into law by President Johnson on Oct. 15, 1966.

2. FAA still remains a part of the executive branch of the government.
3. The function of the FAA is to regulate and promote civil aviation and to provide for the safe and efficient use of the airspace by civil and military aircraft.

Bryan, pp. 114-116;
Frederick pp. 116-117;
Bernardo, pp. 94-104
Above and Beyond, Vol. 5. pp.797-802.

    a. Allocates and regulates the use of navigable airspace.
    b. Acquires, establishes, operates and improves air navigation facilities.
    c. Conducts related research and development.
    d. Makes all safety rules.
    e. Rules on location or substantial alteration of any military or civil airport, rocket or missile site involving expenditure of federal funds.
    f. Issues airman, aircraft, and airline operating certificates; inspects and rates air agencies and facilities.
    g. Sets standards, rules and regulations governing mental and physical fitness of airmen and others who support flight activity; designates and trains medical examiners.

4. A continuing major objective is to encourage and foster the development of aviation overseas.
   a. In cooperation with State Department's International Cooperation Administration, provides technical assistance to other countries:
      (1) FAA acts as consultants on the construction and modernization of airports, installation of airways, and navigation facilities, and safety matters.
      (2) They also provide legal and organizational assistance when requested.
   b. FAA trains foreign nationals in the U. S. in all phases of aviation and gives them practical experience before they return to their own countries.

D. The National Aeronautics and Space Administration

Above and Beyond, Vol.9, pp.1649-1657
Aeronautical Statutes and Related Material, pp. 209-222
Bernardo, pp. 104-105, 206-247

1. NASA was organized and began to function October 1, 1958.
   a. Took over NACA; its five laboratories became field activities.
   b. Also transferred to NASA were various activities from the Dept. of Defense:
      (1) Naval Research Laboratory's Project Vanguard.
      (2) The Jet Propulsion Laboratory managed by the California Institute of Technology.
      (3) George C. Marshall Space Flight Center
   c. The Goddard Space Flight Center was organized and located at Greenbelt, Maryland. — NASA Facts
   d. A NASA Operations Center was established at Cape Canaveral -- its name later changed to John F.Kennedy Space Center at Cape Kennedy. — NASA Facts
   e. The Manned Spacecraft Center was established at Houston, Texas. — NASA Facts
   f. Electronics Research Center was established at Cambridge, Mass.

"This is NASA"

2. NASA conducts aeronautical and space activities and research into problems of flight within and outside the earth's atmosphere.
3. In science, interest centers on:
   a. The properties of the earth.
   b. Earth-sun relationships.
   c. The moon.
   d. Space environment.
   e. The physical nature of the universe.
   f. The possibilities of life in space.
4. In technology, NASA is concerned with providing knowledge pertinent to spacescraft and launch vehicles, aircraft, propulsion, space power, human factors and electronics.
5. In the applications area, work continues in support of meteorology and communication systems.
6. NASA has assisted in the development of V/STOL and other aircraft, including the supersonic transport.

E. International Civil Aviation Organization (ICAO)

Memorandum on ICAO; The Story of the International Civil Aviation Organization.
Bernardo, pp. 107-111
Above and Beyond, Vol.7, pp. 1190-1191

1. ICAO is the outgrowth of an international convention held in Chicago in November, 1944, to consider problems of international aviation.
   a. This convention established an organization to foster and guide civil aviation throughout the free world.
   b. ICAO came into being in April 1947 with headquarters in Montreal, Canada.
   c. Basically, ICAO is an organization comprised of governments representing their airlines.
2. All nations are welcome to become members provided that they agree to adhere to principles of the Chicago Convention and accept the corresponding responsibilities.

   - a. All member states of ICAO are sovereign and equal.
   - b. Although ICAO is considered a specialized agency of the U.N., membership in the UN is not prerequisite for membership in ICAO.

3. An Assembly, which meets annually, is the organization's legislative body.
   - a. Each state has one vote.
   - b. The Assembly elects a Council of 21 members to serve as the executive body.
4. The Council, which remains in virtually continuous session, has two main committees:
   - a. The Air Navigation Committee handles such items as:
     - (1) Technical phases of international air operations.
     - (2) Aircraft airworthiness.
     - (3) Airways systems and traffic control.
     - (4) Licensing of flight personnel.
     - (5) Standardizing maps.
     - (6) Search and rescue procedures.
     - (7) Accident prevention and investigation.
   - b. The Air Transport Committee handles the political and economic phases of international air transportation, such as agreements and contracts.
   - c. The Council may act, if requested, as a tribunal for settlement of certain international disputes.

5. In addition to the above, ICAO has other functions.
   - a. It considers peculiar regional requirements and problems.
   - b. It may provide financial and technical aid for the maintenance of air-navigation and air-transport facilities.
   - c. Ways are sought to minimize and eliminate red tape of customs, immigration and public health.
   - d. It is concerned with the development of international law.

6. United States participation in ICAO is carried out through the Dept. of State.
    a. FAA provides technical expertise.
    b. U. S. positions on international proposals are cleared with the government and with industry through an interagency group.
        (1) Chairman of this group is the Administrator of the FAA.
        (2) Permanent members are representatives of Departments of State, Defense, Commerce, and the CAB.

Federal Aviation Administration's Annual Report.

F. The International Air Transport Association (IATA)
    1. IATA was organized in Havana, Cuba, in April 1945 as the successor to the International Air Traffic Assn. founded in 1919 at The Hague.
    2. IATA is a voluntary association of airline companies with headquarters in Montreal, Canada.
        a. Membership is open to any airline that is licensed to carry cargo, mail, and passengers in scheduled service between two or more countries.
        b. Domestic airlines may join as associate members, participating to a limited extent in IATA activities.
        c. Associate, nonvoting membership is also open to any other air transport enterprise in international operations.
        d. IATA is supported entirely by membership dues.
    3. Basic policies are laid down by an annual meeting.
        a. Each active member company has a single vote.
        b. Continuing affairs are vested in an Executive Committee elected for three-year terms.
    4. The creating work of IATA is done largely by its four committees:
        a. The Traffic Committee is responsible for establishing international tariffs and rates.
        b. The Finance Committee is a clearing house. It also sets up standards of liability insurance and eliminates double taxation.

Cohen, IATA, The First Three Decades.

Above and Beyond, Vol.7, pp. 1188-1189.

        c. The Legal Committee has the general duty of simplifying laws and legal procedures.
        d. The Technical Committee works in all phases of airline and airport operations. This includes:
            (1) Meteorology and communications.
            (2) Standards of performance and maintenance of air and ground equipment.

III. Aerospace Manufacturing Industry

A. Includes all research, development, fabrication, assembly, and sales operations relating to:
    1. Aircraft
    2. Aircraft engines
    3. Parts and accessories
    4. Missiles
    5. Spacecraft
    6. Oceanology

Bryan, pp. 2 - 5
Above and Beyond, Vol. 1, pp. 29 - 32
Aerospace Industries Assn. Aerospace Facts and Figures

B. This industry is the largest employer in the United States.
    1. Employment rose from 780,000 in 1954 to over 1,400,000 in 1968.
    2. Several hundred thousand new jobs have been created since 1950 by advances in technology.

C. Sales average billions of dollars every year.
    1. Over three-fourths of products and services goes to the government or government-related customers.
    2. Despite high sales to government, the industry is still a highly competitive, free enterprise.
    3. Backlog of orders for aircraft and space products indicates continued high sales.

Above and Beyond, Vol. 4, pp. 671-675

D. Career opportunities exist for nearly every skill.
    1. Professional and technical personnel are needed:
        a. Engineers
        b. Physicists
        c. Mathematicians
        d. Metallurgists
        e. Computer Programmers

Zaharevitz and Marshall, Aviation -- Where Career Opportunities are Bright pp. 33-44

Career Opportunities: Engineering Technicians pp. 60 - 83

2. Skilled and semi-skilled personnel are needed:
    a. Tool and die makers
    b. Sheet metal workers
    c. Machine tool operators
    d. Welders
    e. Assembly line production workers
    f. Machine and building maintenance men.

IV. The Airport System

A. Needs for Airports
1. Aviation must have airports, for every trip must begin and end at an airport or landing strip.
2. Airports are needed to serve as terminals for the movement of goods and passengers and the safe handling, servicing, and maintaining of the aircraft.
3. The usefulness of an airport depends upon other airports in nearby towns and cities.

Above and Beyond, Vol.1, pp. 93-102
Bernardo, pp. 114-129
Whitnah, pp. 106, 225-226.

Have students examine an air route map to see how important one airport is to another.

B. Developing a System of Airports
1. Prior to World War I airports were almost non-existent; the air mail system developed by the Post Office in 1918 caused communities to build airports.
2. During the depression, $393,306,703 in federal funds were spent on airport development as part of the work relief programs.
3. Prior to this, local communities built airports; government merely advised and inspected completed facilities.
4. By 1938 the CAA was requested by Congress to survey airport situations and make recommendations for improvement.
    a. World War II delayed recommendations.
    b. Funds were made available for development or improvement of civil airports which had military significance or were required for defense purposes.
    c. In all, $402,873,870 in federal funds went into such airports, but a national system was still not established since these airports were concentrated in southern and coastal states.

Frederick, pp. 40-44.

Film, "One World Way."

5. Federal Airport Act was passed by Congress in 1946.
    a. It authorized the Federal Government to spend five hundred million dollars over a period of seven years (the expiration date was later extended) to be matched by state and local funds.
    b. The expenditures were aimed at establishing a national airport system based on the aeronautical needs of the communities as related to the national scene.
    c. The Act stressed inclusion of smaller cities in the airport system.
6. The basic Airport Act was amended in 1955 and several times since then.
    a. The Act authorized the expending of definite amounts for federal participation in airport development as part of the national transportation system.
    b. The Act enables communities to meet the present and future needs of civil aviation for airport development under the Federal Aid to Airports Program.
    c. In administering the Program, the FAA coordinates its activities with other government agencies and bodies:
        (1) The CAB and Dept. of Defense to bring together the policies and programs of the three agencies that affect airport development.
        (2) The Housing and Home Finance Agency.
        (3) Regional and local planning agencies.

See Federal Aviation Administration Annual Reports for program expenditures and obtain current copy of FAA's National Airport Plan. Also, Burkhardt, Chapt. 9

FAA Film, "Best Investment We Ever Made"

C. Classification of Airports in the United States (Airports are grouped by their functional use in the community)
    1. Utility Airports. -- general aviation use only.
        a. Basic Utility. Serves about 95% of propeller aircraft under 12,500 pounds gross weight. Serves medium size population areas.
        b. General Utility. Accommodates all propeller aircraft of less that 12,500 pounds. Serves communities located on fringes of metropolitan areas.

FAA Advisory Circulars:
AC 150/5300-4A
AC 150/5300-6

2. Transport Airports. -- General aviation use only.
   a. Basic Transport. Accommodates turbojet-powered airplanes up to 60,000 pounds. Used by business, corporate and executive jets.
   b. General Transport. Accommodates transport category airplanes up to 175,000 pounds.
3. Air Carrier Airports.
   a. Used by all segments of civil aviation with air carrier operations critical for airport design.
   b. Dimensional standards are determined by the type of service provided and physical and operational characterists of aircraft using the airport.

FAA Statistical Handbook of Aviation

4. Heliports. Designated landing and takeoff area for helicopter operations.

Above and Beyond Vol. 1, pp 93-102

5. STOL ports. Accommodates aircraft capable of very steep climbs and descents and of using very short runways or small areas for takeoffs and landings.

6. Seaplane bases. Designated landing and takeoff water area for private and commercial operations.

Have students determine the kind of service for which their local airport is designed.

D. Airport Management
   1. Airports receive income from many sources including:
      a. Landing fees from commercial operators.
      b. Hangar rental and aircraft tiedown charges.
      c. Fixed base and other flying operations handled on a concession basis
      d. Gasoline and oil sales.
      e. Concessions: food, car rentals, air travel insurance, etc.
      f. Leasing non-operational land for agricultural purposes.

Frederick, pp. 54-56

- g. Aircraft, parts, and accessories sales.
- h. Repair, overhaul, and maintenance.
- i. Space rental in terminal buildings.
- j. Industrial area rentals on various sections of the airport.
- k. Ground transportation franchises for the transport of passengers.

2. Airports have high expenses.
   - a. Original investments are high in land and improvements.
   - b. Airports must continually update facilities and services.
   - c. Airports must maintain runways, drainage, access roads, buildings.
   - d. Certain localities have high expenses in snow removal.
3. Airports must be planned carefully to avoid problems with the community.
   - a. Zoning should be established to prevent building of homes in proximity to airport.
   - b. Zoning must be convenient for industry and other airport users.
   - c. Access roads, local transportation and, if necessary, railroad spurs must be provided.
   - d. Noise abatement must be considered. Control can be exercised by:
     - (1) Runup procedures in certain locations.
     - (2) Restricted hours of operation.
     - (3) Takeoffs and landings away from populated areas.
     - (4) Blast fences to reduce noise and jet blasts.
   - e. Building codes must prevent construction of towers, tall buildings, and other obstructions near the airport or in the traffic pattern.

V. The Airlines

A. The Domestic Trunk carriers include those carriers that presently have permanent operating rights within the continental United States.

1. Most carriers operate high density routes.

Refer to latest FAA Statistical Handbook of Aviation for number of passengers and ton-miles and Air Transport Facts and Figures, for names of carriers in each case.

2. They carry mail, express, and freight on passenger flights as well as on all-cargo flights.

B. The Domestic Local Service carriers operate routes of lesser traffic density between the smaller traffic centers and between these centers and principal centers.

C. Intra-Hawaiian carriers operate between the several islands comprising the State of Hawaii.

D. The Intra-Alaskan carriers provide service within the State of Alaska.

E. The Helicopter carriers operate between airports, central post offices, and suburbs of New York, Chicago, Los Angeles, and San Francisco.
    1. Originally certified as exclusive mail carriers, they now fly passengers, air freight, air mail, and air express.
    2. Operated on government subsidies until 1967.

F. The International and Territorial lines include all U. S. Flag air carriers operating between the United States and foreign countries other than Canada, and over international waters.
    1. Some conduct operations between foreign countries.
    2. Some are extensions of domestic trunk lines such as those into Mexico, the Caribbean, Alaska, and Hawaii.

G. The All-Cargo carriers operate scheduled flights carrying freight, express, and mail between designated areas in the U.S.; one carrier flies to the Caribbean and another to Europe.

H. Supplemental Air carriers hold temporary certificates issued by the CAB authorizing them to perform passenger and cargo charter services as well as scheduled operations on a limited or temporary basis; they supplement the scheduled service of the certificated route carriers.

I. Intra-state Air carriers operate as common carriers.
   1. Operations are limited to an area within the boundaries of a particular state.
   2. Operating authority is granted by the state.

J. Air Freight Forwarders are classified as indirect air carriers.
   1. They are engaged in the assembly and consolidation of cargo for transportation by an air carrier.
   2. There are approximately 100 forwarders operating in domestic interstate and foreign commerce.

K. All air carriers except air taxi operators and air freight forwarders operate charter flights for group tours or for special cargo flights.

L. Through bilateral agreements, foreign carriers fly into several U.S. cities.
   1. In 1950 there were just over 1 million air passengers between the U.S. and foreign countries.
   2. By 1968 there were over twelve million such passengers -- 62% were U.S. citizens.

M. The Civil Air Reserve Fleet represents the airlines' part in national defense.
   1. Most airlines have allotted a certain number of its planes to the CARF in case of national emergency.
   2. Long-range airliners will be dispatched to pre-arranged bases on 36-hours notice.

N. The airline route pattern has been developed since 1938.
   1. When the Civil Aeronautics Act was adopted in 1938, individual routes were flown by single airlines.

Frederick, pp.95-103.

    a. Function of CAB is to create competition, so now most routes are served by more than one carrier.
    b. Route competition comes about in a number of ways:
        (1) CAB authorizing new routes or extensions.
        (2) Operations of supplemental and all-cargo carriers.
        (3) Authorization by the CAB of additional air carrier operations.
2. Most problems have developed from changes in the sizes of airlines and their equipment, and from desires for more nonstop services.
    a. Original route pattern was developed when DC-3 was basic aircraft flown.
    b. Domestic system consisted of only three sizes of carriers -- the very large, the intermediate regional, and the small local airlines.
3. Changes in routes (adding or dropping certain routes) are determined in hearings before the CAB.
4. International route patterns have been established as the result of a comprehensively planned series of proceedings before the CAB.
    a. There is increased competition between U.S. and international carriers.
    b. Extensive competition arises between U.S. carriers and foreign-owned carriers.
        (1) Extension of our carriers into new areas.
        (2) Increase in the number and extent of foreign flag carriers.

O. Employment opportunities in air transport encompass many types of work.
    1. At the present time there is a shortage of aviation mechanics, avionics and radar instrument technicians, all of whom need advanced training.
    2. Jobs usually exist for ground support people such as fuelers, baggage handlers, maintenance, communications, reservations, dispatchers, and general office, many of whom require only a high school diploma.

NAEC, Career Opportunities in Aviation; ATA, "Your Career with the Airlines"; UAL, "Your Future in Air Transportation"; Janey, "Professional Pilot Career Bulletin."

VI. General Aviation

Above and Beyond, Vol. 6, pp. 953-968
Bernardo, pp. 56-76
Bryan, p. 6

A. General aviation includes all civil flying except that done by the certificated, supplemental, intrastate carriers and the FAA.

B. General aviation represents the largest portion of all civil flying in the U.S.
   *1. FAA records show more than 124,000 airplanes are flown by businesses and individuals compared to the fewer than 3,000 registered aircraft flown by all airlines combined.
   *2. Active airman (pilots) certificates are held by 691,695 individuals.
   *3. More that 10,400 airports are used by general aviation, while fewer than 525 airports are served by scheduled airlines.
   *4. During 1968 manufacturers produced 13,698 general aviation aircraft valued at more than $421.5 million during the year, 17 percent higher than 1967 net billings. Exports continued strong with the sale of 2,879 aircraft valued at nearly $101.3 million reflecting the growing requirements for these aircraft throughout the world.

See latest edition of FAA Statistical Handbook of Aviation, for exact number of planes, miles flown, etc.

"The New Dimension in Your Life"

*These statistics are as of December 1968

C. Air taxi operators offer transportation on a demand basis.
   1. They operate aircraft under 12,500 pounds
   2. They will take passengers and goods to any location that has a suitable airport.
   3. There are an excess of 10,400 airports available for this service in the country today. (Statistics as of Dec. 1968)

D. Commuter air carriers were formerly known as scheduled air taxis. The Civil Aeronautics Board recognized their transportation capabilities and redesignated this group of operators who offer a service on a regularly scheduled basis between designated points as commuter air carriers.

E. Business flying represents the use of aircraft as transportation vehicles in the conduct of business.
   1. Aircraft, sometimes whole fleets, are owned or leased by a company or individual, and include jets.
   2. Of the total active general aviation aircraft, nearly one-fourth are engaged in business flying.
   3. Business flying accounts for the largest number of total miles and total hours flown by general aviation aircraft.
   4. More and more businesses are finding it economical and expedient to use aircraft to transport executives and materials from one plant to another.

Have the students make a list of businesses that could benefit economically from owning a plane.

F. Personal flying represents the use of aircraft for private use, not for hire.
   1. Personal flying is in second place as to number of miles and hours flown.
   2. 53% of active general aircraft were used for personal flying.

Have the students make a list of ways people use an airplane for personal use (hunting, vacations, etc.)

G. Instructional flying represents the flight training of civilians in dual and solo flying under an instructor's supervision

Have the students look up the required number of hours of instruction for various kinds of licenses.

H. Commercial flying includes special purpose transport, aerial application, fire flighting, patrol and surveys.
   1. This type of flying is generally performed on a for-hire basis by fixed base operators who specialize in one of these activities.
   2. Nearly 60,000 aircraft are flown in general aviation business and commercial activities.
   3. Special purpose flying includes the use of aircraft in:
      a. Construction
      b. Flying ambulance
      c. Search and rescue
      d. Dropping fish minnows into lakes that are inaccessible by road.
      e. Moving or herding livestock.
   4. Aerial application includes spreading insecticides, pesticides, fertilizers, and seeds by air over farm land. Almost 5,000 aircraft are used in aerial application in the U.S.
      a. Aerial application used by the health services to control mosquitos and other pests.

Contact your local airport fixed base operator to be a quest speaker.

Contact local crop dusting concerns for guest speakers.

- b. Aerial application is fast; can control infestations of insects or counter plant problems (like mold on grapes) rapidly and thus save the crops.
  - (1) The government controls this activity strictly to prevent poisons from accumulating on foods.
  - (2) Cost is relatively low.
  - (3) Saving crops helps keep food costs down.

5. Airplanes and helicopters are now used in firefighting:
   - a. To observe the blaze and direct ground units.
   - b. To drop firefighters into strategic areas.
   - c. To drop water bombs or spread borate solutions directly on the fire area.
   - d. To rapidly move supplies and equipment.
6. Patrol and survey flying is done by and for individual companies and the government.
   - a. Patrol fences, pipelines, irrigation ditches, lakes, and dams.
   - b. Conduct aerial mapping surveys.
   - c. Conduct aerial surveys of wildlife, moving small animals to new locations, supplying food as necessary.
   - d. Conduct ocean patrols to locate schools of fish for the commercial fishing fleets.

I. Career opportunities in general aviation duplicate many of those listed under air transport. These include:
   1. Pilots, flight and ground instructors.
   2. Mechanics.
   3. Instrument and communications technicians.
   4. Ground crews such as fuelers, dispatchers, and office employees.

RESOURCES

Textbooks:

Above and Beyond: The Encyclopedia of Aviation and Space Sciences. Chicago: New Horizons Publishers, Inc., 1968.

Bernardo, James V., Aviation and Space in the Modern World, New York: E.P. Dutton & Co., Inc., 1968.

Bryan, Leslie, et al, Fundamentals of Aviation and Space Technology, Urbama. Ill. Aviation Institute, University of Illinois, 1968 edition.

Burkhardt, R., The Federal Aviation Administration. New York: Frederick A. Praeger, 1967.

Cohen, S. Ralph, IATA. The First Three Decades.

Frederick, John H., Commercial Air Transportation, Homewood, Ill. Richard D. Irwin, Inc., 1961.

Memorandum on ICAO: The Story of the International Civil Aviation Organization.

Whitnah, Donald R., Safer Skyways, Ames, Iowa: Iowa State University Press, 1966.

Career Guides:

"Aerospace, a New World of Careers," Occupational Quarterly Outlook, May 1966, U. S Department of Labor, Bureau of Labor Statistics, Washington, D. C. 20212. (35¢)

"AVIATION - Where Career Opportunities are Bright". A filmstrip and record together with a very detailed Counselor's Guide. Available from National Aerospace Education Council, 806 15th Street N.W., Washington, D. C. 20005 Price $10.00 for complete package.

Career Opportunities in Aviation, National Aerospace Education Council, 806 15th St., NW., Washington, D.C. 20005 (50¢)

"Career Opportunities - Engineering Technicians" and "Career Opportunities--Community Service and Other Specialists". These publications are parts of a series of volumes on career opportunities, edited by Walter J. Brooking and published in 1969 by J. G. Ferguson Publishing Company, 6 North Michigan Avenue, Chicago, Illinois 60602. $8.95 each volume.

Peters, Herman J., et al, Seven Steps to a Career in Space Science and Technology, prepared for the National Aeronautics and Space Administration, 1966, Government Printing Office, Washington, D. C. (45¢)

Your Career with the Airlines, Air Transport Association of America, 1000 Connecticut Ave., Washington, D.C. 20036. (Free)

Zaharevitz, Walter, and Marshall, Jane N., "Aviation-Where Career Oportunities are Bright, Counselor's Guide, National Aerospace Education Council, Washington, D. C. 1968. ($3.00)

Reference Books and Information:

Aerospace Facts and Figures (annually) and "Aerospace" (quarterly) Aerospace Industried Assn., 1725 DeSales Street, N.W., Washington, D. C.

Air Transport Facts and Figures (annually), Air Transport Assn. of America, 1000 Connecticut Avenue, N.W., Washington, D. C. 20036

Civil Aeronautics Board (CAB), Publications Section, B-22, Washington, D.C. 20428:

- List of Publications, Civil Aeronautics Board. (annually). No charge.
- Civil Aeronautics Board. (Organization and functions). Issued April 1967, amended August 1968. No. Charge.
- A Study of the Domestic Passenger Air Fare Structure. Issued Jan. 1968. No charge.
- An Introduction to Airfreight Rates. Revised Sept. 1968. No charge.

The Civil Aeronautics Board Promotes and Regulates the Airline Industry. Issued April 1967. No Charge for five copies or less.
CAB Chart Book of Airline Economic Trends. Calendar years 1955 through 1966. Issued September 1967. No charge.

Civil Aeronautics Board documents available from the Government Printing Office, Washington, D. C. 20402. Make check or money order payable to: "Superintendent of Documents ":
Handbook of Airline Statistics, (C 31.249:967)(every 2 years). Issued February 1968. $5.50.
Aeronautical Statutes and Related Material, (C31.205:Ae 8/967). Amended to May 1, 1967. $1.25.
Federal Aviation Administration. Documents available from the Government Printing Office, Washington, D. C. 20402. Make check or money order payable to: "Superintendent of Documents ":
FAA Statistical Handbook of Aviation. Annual. $2.75
National Airport Plan. Annual. $1.50.
FAA's Historical Fact Book, a Chronology 1926-1963. $1.00
Federal Aviation Administration, Department of Transportation, TAD 484.3, Washington, D. C. 20590 :
Annual Report of Operations under the Federal Aviation Administion.
Federal Airport Act. No charge.
FAA Certificated Mechanic School Directory. AC 147-2E. No charge.
Opportunities in Air Traffic Control; Do You Qualify? No charge.

Federal Aviation Administration, Office of General Aviation Affairs, Aviation Education, GA-20, Washington, D. C. 20590 :
Your Career in Aviation (GA-20-22) No charge.
Aviation and Transportation - Courses and Majors Offered at Institutions of Higher Learning, (GA-20-72). No charge.
International Air Transport Association, Facts About IATA Terminal Centre Building, Montreal 3, Quebec, Canada No charge.
*National Aeronautics and Space Administration, Educational Publications (EP Series). No charge.

EP-6	"Space: The New Frontier."
EP-20	"Educational Guidance in the Space Age."
EP-22	"This is NASA."
EP-33	"Seven Steps to a Career in Space Science and Technology."

NASA Facts Organization series - no charge.

NF-21	"V/STOL Aircraft"
0-2	"NASA Ames Research Center."
0-4	"NASA Flight Research Center."
0-5	"NASA Goddard Space Flight Center."
0-6	"NASA John F. Kennedy Space Center."
0-7	"NASA Langley Research Center."
0-8	"NASA Lewis Research Center."
0-9	"NASA Manned Spacecraft Center."
0-10	"NASA George C. Marshall Space Flight Center."
0-11	"NASA Wallops Station."

National Aerospace Education Council, Sources of Free and Inexpensive Pictures, Pamphlets and Packets for Aviation and Space Education. 806 15th Street N.W., Washington, D.C. 20005.50¢

The Utility Airplane Council, Aerospace Industries Association, 1725 DeSales St., NW, Washington, D.C. 20036: "The New Dimension in Your Life"

Air Transport Association of America, 1000 Connecticut Ave., Washington, D.C. 20036: "The Promise of International Air Commerce" by Stuart G. Tipton.

Transworld Airlines: "Doorway to the Sky". Air World Education Series No. 1, 380 Madison Avenue, New York, N.Y.

*See page 245 for address.

Films:

*Federal Aviation Administration:

"Flight" (FA-117). 1962, Color, 28 min. A non-technical general view of the FAA's mission and responsibilities.

"Dulles International - Port of the Future," (FAC-121) 1965, Color. 14 min.

"The Best Investment We Ever Made," (FA-304). Describes the economic benefits of general aviation airports. 1964, color, 23 min.

"Aviation Mechanic," (FA-315). Describes the varied skills and opportunities found in civil aviation today. 1964, Color, 17 min.

"The Other Passenger," (FA-601). Depicts the duties of an FAA Flight Operations Inspector as he observes the flight crew of a civil jet airliner. 1965, Color, 30 min.

"How About Billy Wilson?"(FA-617). Describes career opportunities within FAA for a young minority group student. Highlighted is the requirement that aspirants for FAA employment must secure education and training necessary to qualify for professional and technically oriented positions. 1968, B/W, 17 min.

"Aviation Workshop," (FA-605. A behind-the-scenes look at the many functions of the FAA. 1966. Color, 28 min.

*Other Sources:

"One World Way," - Los Angeles Dept. of Airports - Describes the history and management of airports.

"Wings at Work," - Lockheed-Georgia Company - A historical and modern story of business and commercial aviation. Color, 28½ min.

*See page 233 for addresses.

INTRODUCTION

The study of Aeronautical Science will not be complete if flight experience is denied the student. Therefore, every attempt should be made by the teacher and the school administration to promote and arrange for this "laboratory" experience.

Those public schools that have participated in flight indoctrination can document the favorable results of such activities. They can point to numerous graduates who are now making major contributions to our society and are successful in their area because of the motivating effect of indoctrination flights.

This flight experience affords the student an opportunity to use effectively the knowledge gained in classroom study. It is a meaningful adjunct to the classroom; in fact, it is the laboratory experience which is a necessary part of any science course.

TO THE TEACHER

In a well planned flight curriculum, the key words are safety and integrity.

The selection of the fixed base operator to airlift the students is of the utmost importance. Suggested criteria for selection are as follows:

1. Well established as fixed base operator.
2. FAA certificated flight school.
3. Pilots who are vitally interested in this project.
4. Pilots who are thoroughly informed as to the reason for the activity.
5. Equipment that is in superb condition.
6. No flight is to be made when visibility is below three miles and the ceiling below 3000' AGL regardless of the pilot's qualifications.
7. Flights to be conducted at times when the air is relatively smooth.

UNIT OUTLINE

I. Two Indoctrination Flights — See Exhibit # 1

A. 30-minute orientation
1. Only one landing.
2. All students required to perform orientation and check point exercises.
3. Students to observe all pilot duties, flight and engine instruments.

B. 90-minute cross-country flight
1. Triangle course.
2. Landings at two airports and return.
3. For one leg, each student to:
a. Observe all check points
b. Navigate
c. Operate radio
d. Handle controls
e. Compute TC, CH, GS, GPH
4. Each student to receive a grade on the leg for which he was responsible.

II. Preparation for Flight

A. Pre-flight check for both flights — See Exhibit # 2

B. On cross-country flight
1. Prepare but not file: a flight plan. — See Exhibits #3 & #4
2. Prepare all required navigation and weather planning.

C. Tower visit
1. If possible, students to visit the tower for a period of approximately 15 minutes in groups not exceeding 5.
2. Students to observe:
a. Ground control operation
b. Air traffic control
c. Radio frequencies
d. Light signals
e. Emergency procedures
f. Wind indicators
g. Altimeter setting indicators

III. Contractural Requirements

Following are excerpts from a contract entered into by a school district and a flight operator. This contract, in its complete form, has been approved by a county council and has served as an official agreement for several years.

These phrases are presented in this course of study only with the intention that they serve as a guide for schools desiring to implement a flight indoctrination program.

Furthermore, a letter and forms are sent to the parents of students who intend to fly, with further information regarding school responsibility. These forms stand on their own merit, need no further explanation, and are included as exhibits 5, 6, and 7.

Excerpts

"...equal amounts of flight experience for each such student."

"...in no event shall flight experience be provided on any day which the schools of the District are not permitted by law to be open."

" Flight experience will be provided only for the number of students agreed upon herein and contracted for."

" All flight experience will be provided by the Foundation in aircraft operated by commercial pilots with flight instructor ratings..."

" The operator may at his discretion, refuse to fly any particular student if in the opinion of the operator such flight would constitute a hazard to the aircraft, to the student, or to others."

" With respect to each student presented for flight experience the District shall furnish the operator with a consent and release form approved by the operator, executed by the student and by his or her parents."

" In no event shall any officer, agent or employee of the District be personally or individually liable in any respect as to any term, condition or covenant contained in this agreement, it being mutually understood and agreed that the action of each and every officer, agent or employee of the District is in his official capacity as such."

Excerpts (Cont'd)

" The District shall accurately make a record of the flight experience received and shall periodically report to the Division of Aeronautics in accordance with Section 8402 of the Education Code."

" Not more than three (3) students will be flown in any one aircraft at any one time."

" No such aircraft shall have been declared by any federal agency to be surplus."

" Each such aircraft shall have a total horsepower rating of not less than 145 horsepower and not more than 245 horsepower."

" Certificated periodic inspections of each aircraft shall have been regularly made in accordance with Federal Air Regulations."

" The operator will maintain liability insurance covering the operations contemplated by this agreement, with respect to which insurance the District shall be listed as an additional named insured. Such insurance shall be paid for by the operator and shall be at least in limits* as follows:

Bodily injury, excluding passengers.......	$100,000 each person $300,000 each occurrence
Bodily injury, passengers...............	$ 40,000 each seat $400,000 maximum per accident
Property damage.........................	$100,000"

" Evidence of the above-described insurance coverage shall be filed with the District (prior to flight experience)..."

" The obligation of the operator to provide flight experience pursuant to this agreement shall be excused to the extent a flight or flights are prevented by reason of the weather, and by reason of other circumstances beyond reasonable control of the operator."

*These limits are exceeded by some operators in California for schools and colleges that are offering flight instruction. One provides a five million dollar aggregate liability coverage for any one accident.

EXHIBIT # 1

30-MINUTE INDOCTRINATION FLIGHT

Date______________________________
Alternate Date____________________

CHECK POINTS

1. PRE FLIGHT
2. GROUND CONTROL 121.7 - ENGINE CHECK
3. TORRANCE TOWER 120.9 -- NORTH R'WY
   124.0 -- SOUTH R'WY
4. STRAIGHT OUT DEPARTURE
5. KING HARBOR
6. R.U.H.S. CAMPUS
7. EDISON PLANT
8. LAX 118.9
9. COLISEUM
10. HARBOR FREEWAY
11. L.A. RIVER - TURN SOUTH
12. SIGNAL HILL - LONG BEACH AIRPORT - SKYLINE
13. L.A. HARBOR - NAVY SHIPS
14. PALOS VERDES AND CATALINA
15. STRAIGHT IN APPROACH - OVER BIG "T"

Locate each "check point" and topographical feature indicated.

NOTE Do Not Touch Propellers
Keep Safety Belt On
Call Out Other Aircraft In Air To Pilot

Note Compass Heading - Airspeed - Landing Speed - Altitude - Rate of Climb - Tachometer

EXHIBIT # 2

IV. Pre-Flight

A. Cockpit check
1. Magnetos off
2. Throttle closed
3. Mixture lean
4. Master off

B. Exterior airplane check
1. Start near the left door
2. Left wheel assembly
   a. Fitting for hydraulic fluid
   b. Tire for air pressure, cuts, and wear
3. Drain left fuel strainer. Drain 3 seconds - check for water
4. Lower flaps all the way
   a. Slots clean and rollers free
   b. Flap drive rod connected
   c. Raise flaps
5. Ailerons
   a. Hinges, full travel, freedom, sound, and alignment
   b. Use caution while actuating controls
6. Navigation light (left red) secure
7. Leading edge of wing - dents
8. Wing strut solid - fittings
9. Fuel tank vent clean and solid
10. Pitot tube clean and solid
11. Static source hole clean
12. Propeller: inspection for nicks on cold days; if plane has not been flown earlier in day, prop to be pulled through 6 to 8 blades

ALWAYS CONSIDER PROP MAY BE HOT!

NEVER pull prop through until you have been taught how!

13. Frontal view: obstructions to in-takes
   a. Leaves, rags, paper, nests, tools, etc.
   b. At a distance of 25 or 30 feet, plane to be viewed for symmetry
14. Under hood - right side
   a. All wires and lines connected
   b. Oil leaks
   c. Drain gascolator 4 or 5 seconds - check for water
   d. Check oil - OIL CAP ON TIGHT
   e. Secure cowling door
15. Nose tire - air pressure, cuts wear
   a. Fittings and hydraulic fluid
   b. All lock-nuts keyed

16. Wing: same inspection as for other wing.
17. Body: inspection for dents, wrinkled skin, antennae secure.
18. Top of wings: inspection for ripples, or gouges.
19. Tail assembly
    a. Leading edge, horizontal and vertical stabilizer.
    b. Underside: cuts, gouges, and ripples.
    c. Elevators: hinges, nuts, trim tab, travel, and sound.
    d. Rear view inspection from 25 or 30 feet.
20. Inspection of opposite side of fuselage, same as 1 through 8.
21. Inspection and securing of gas caps (use ladder).
22. Windows to be washed.
    a. Gasoline, oil, or dirty rag mar plexiglas.
    b. Use a clean cloth.
    c. Use plexiglas wax cleaner.
    d. DO NOT USE DRY CLOTH ON DRY WINDOW.
23. Move the plane so the engine blast does not blow other planes, open hangers or mechanics.
24. All chocks removed, wings and tail untied. Enter plane.
25. Taxi slowly. Turn without using brakes, if possible.

PILOT'S PLANNING SHEET

Plane Identification **Date**

CRUISING AIRSPEED	TC	WIND MPH	WIND FROM	WCA R+ L−	TH	VAR W+ E−	MH	DEV	CH	TOTAL MILES	GS	TOTAL TIME	FUEL RATE	TOTAL FUEL
From:														
To:														
From:														
To:														

VISUAL FLIGHT LOG

TIME OF DEPARTURE	RADIO FREQUENCIES	DISTANCE	ELAPSED TIME	CLOCK TIME	GS	CH	REMARKS
POINT OF DEPARTURE	TOWER / RANGE	POINT TO POINT / CUMULATIVE	ESTIMATED / ACTUAL	ESTIMATED / ACTUAL	ESTIMATED / ACTUAL	ESTIMATED / ACTUAL	BRACKETS, WEATHER, ETC.
CHECKPOINTS 1.							
2.							
3.							
4.							
5.							
DESTINATION 6.							

The Pilot's Planning Sheet provides space for entering dead-reckoning data.

The Visual Flight Log may be prepared in advance by entering the selected checkpoints, together with the following data: Distance between checkpoints, and cumulative distance; estimated time between checkpoints; clock or cumulative time; groundspeed and Compass Heading.

As the flight progresses, the actual time, groundspeed and Compass Heading should be filled in, thus completing the log.

EXHIBIT # 4

FEDERAL AVIATION AGENCY

FLIGHT PLAN

Form Approved.
Budget Bureau No. 04-R072.3

1. TYPE OF FLIGHT PLAN
☐ FVFR ☐ VFR
☐ IFR ☐ DVFR

2. AIRCRAFT IDENTIFICATION

3. AIRCRAFT TYPE/SPECIAL EQUIPMENT 1/

4. TRUE AIRSPEED
KNOTS

5. POINT OF DEPARTURE

6. DEPARTURE TIME
PROPOSED (Z)
ACTUAL (Z)

7. INITIAL CRUISING ALTITUDE

8. ROUTE OF FLIGHT

9. DESTINATION *(Name of airport and city)*

10. REMARKS

11. ESTIMATED TIME EN ROUTE
HOURS
MINUTES

12. FUEL ON BOARD
HOURS
MINUTES

13. ALTERNATE AIRPORT(S)

14. PILOT'S NAME

15. PILOT'S ADDRESS AND TELEPHONE NO. OR AIRCRAFT HOME BASE

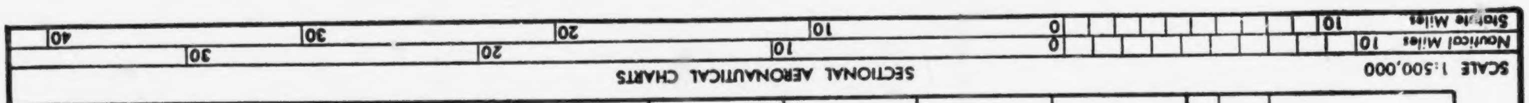
16. NO. OF PERSONS ABOARD

17. COLOR OF AIRCRAFT

18. FLIGHT WATCH STATIONS

CLOSE FLIGHT PLAN UPON ARRIVAL

1/ SPECIAL EQUIPMENT SUFFIX
A — DME & 4096 Code transponder
B — DME & 64 Code transponder
D — DME
L — DME & transponder—no code
T — 64 Code transponder
U — 4096 Code transponder
X — Transponder—no code



PILOT'S PREFLIGHT CHECK LIST

DATE

WEATHER ADVISORIES
EN ROUTE WEATHER
DESTINATION WEATHER
ALTERNATE WEATHER
FORECASTS
WINDS ALOFT
NOTAMS
AIRSPACE RESTRICTIONS
MAPS

FLIGHT LOG

DEPARTURE POINT
VOR: IDENT. / FREQ.
RADIAL: TO / FROM
DISTANCE: LEG / REMAINING
TIME: PT-TO-PT / CUMULATIVE
TAKEOFF
ETA
ATA
GROUND SPEED
CHECK POINT
DESTINATION
TOTAL

POSITION REPORT: FVFR report hourly, IFR as required by ATC
ACFT. IDENT. | POSITION | TIME | ALT. | IFR/VFR | EST. NEXT FIX | NAME OF SUCCEEDING FIX | PIREPS

REPORT CONDITIONS ALOFT—
CLOUD TOPS, BASES, LAYERS, VISIBILITY, TURBULENCE, HAZE, ICE, THUNDERSTORMS

CLOSE FLIGHT PLAN UPON ARRIVAL

SCALE 1:1,000,000 WORLD AERONAUTICAL CHARTS

SCALE 1:500,000 SECTIONAL AERONAUTICAL CHARTS

Nautical Miles 10 0 10 20 30 40 50 60 70 80
Statute Miles 10 0 10 20 30 40 50 60 70 80 90
Nautical Miles 10 0 10 20 30
Statute Miles 10 0 10 20 30 40

EXHIBIT # 5

Dear Parents:

Aero Science students of Redondo Union High School are preparing to start their "flying classroom" schedule for this semester. The principal and the Aero Science instructor have looked forward to the time when your son or daughter could participate in this valuable phase of aeronautics learning on May 12 or 13.

Under this program students have the opportunity to spend an afternoon at the Torrance Airport where they will learn some of their lessons first-hand, and will be given the experience of flight in a modern four place plane. The schedule provides for either a 30 minute or a 90 minute flight experience for students in the Aero Science class. In the 90 minute flight, students will assist in the navigation. The pilot will be in complete control at all times.

Students will provide their own transportation to and from the airport. In case of unsatisfactory weather, flights will be rescheduled either Friday and Saturday, May 19 and 20 or June 2 and 3.

The Aero Science instructor will accompany each group and will supervise the instruction at the airport where the facilities of the control tower will be available. Pilots for the flying experience part of the program are well qualified flight instructors. The Bates Foundation for Aeronautical Education is providing the flight indoctrination program. They are fully certified by the Federal Aviation Administration.

To be eligible for this valuable experience, your son or daughter must maintain good standing in class and return signed parental permission forms. It should be understood that these flights are not compulsory.

The thought behind the flight indoctrination program is not to make pilots of the Aero Science students, but to create a better understanding of the significance of aviation in today's social and economic world. Los Angeles is the Number One city in aircraft production and the implications of aviation can be best understood by experiencing actual use of this most modern method of transportation.

Very truly,

EXHIBIT # 6

FLIGHT EXPERIENCE PERMISSION BLANK AND RECORD
Redondo Union High School
Aero Science Class

I hereby request that my son/daughter (Name)____________________________ be permitted to participate in the program of flight experience to be held under the auspices of the South Bay Union High School District Board of Education and Redondo Union High School.

I understand that this activity occurs after school hours, is supplementary to the regular class work, and is not required for class credit.

I agree to assume the responsibility in seeing that my son/daughter cooperates and conforms to the fullest with the direction and instructions of the school officials in charge.

The Bates Foundation carries liability insurance in the amount of $1,000,000. The South Bay Union High School District is listed as additional named insured in this policy. In addition to the above, the school district liability insurance covers each student thoroughly.

All flights will originate and terminate at Torrance Airport.

SIGNED____________________________________
(Name of parent or guardian)

ADDRESS____________________________________

TELEPHONE NUMBER____________________________

Note: Every precaution and care has been taken in planning and organizing this activity and the pupil and parent must assume their share of the responsibility.

Flight	Date	Time
30 Minutes		
90 Minutes		

EXHIBIT # 7

To: Redondo Union High School Aero Science Department

Name______________________________has my permission to:

Drive his car____________________

Carry fellow students______________

Ride with______________________
(Name)

to Torrance Airport on May 12, 13, 19, 20, June 2, 3, (whichever date applies) for the Aero Science Course Indoctrination Flights.

SIGNED____________________DATE_____________
Father

____________________DATE_____________
Mother

____________________DATE_____________
Guardian

RESOURCES

Reference Books and Information:

*Federal Aviation Administration, FAA Advisory Circulars:
00-2 "Advisory Circular Checklist," (Latest Revision)
20-5A "Plane Sense," (4-4-67).
20-9 Personal Aircraft Inspection Handbook, (12-2-64).($1.00 GPO)
20-34A "Prevention of Retractable Landing Gear Failures,"(4/21/69)
20-35A "Tie-down Sense," (10-29-68).
60-1 "Know Your Aircraft," (6-12-63).
60-4 "Pilots" Spatial Disorientation," (2-9-65).
61-2A Private Pilot (Airplane) Flight Training Guide,(9-1-64)($1.00, GPO).
61-12C "Student Pilot Guide," (5-31-67). ($0.20 GPO)
61-21 Flight Training Handbook, (1-11-66). ($0.70, GPO).
90-33 "VFR Communications for General Aviation," (11-20-67).
90-35 "Frequency Discipline," (5-17-68).
150/5200-1 "Bird Hazards to Aviation," (3-1-65).

Federal Aviation Administration, Airman's Information Manual. Make check or money order payable to the "Superintendent of Documents" and send to the U.S.Government Printing Office, Washington, D. C. 20402.
Part 1 "Basic Flight Manual and ATC Procedures," (annual subscription ($4.00 GPO)
Part 2 "Airport Directory," (annual subscription $4.00).
Parts 3 and 3A "Operational Data and Notices to Airmen," (annual subscription ($20.00 GPO)

*See page 244 for address and how to obtain copies.

Other Aids:

Sanderson Films, Inc., Wichita, Kansas, Pre-flight Facts, Filmstrips, Records, and Course Manual.

INTRODUCTION

The time is approaching when schools will provide students with district financed flight training as part of the regular curriculum. Until that time arrives, aeronautical science students must arrange for their own flight training.

However, the school can play an important part in an individual flight training program without becoming involved. The school, from its vantage point, will do the students a service if it sees that contact is established between students and reputable flight schools.

Often an agreement among parents can be reached with a fixed base operator that will provide the best training at a reduced rate. However, it should be noted that the least expensive flight training package is seldom the most desirable.

Included in this outline is a sample letter to parents suggesting the idea of flight training for their son or daughter.

TO THE TEACHER

A planning session is recommended in which the classroom teacher and the chief instructor at the flight school will plan to coordinate the order of presentation of ground school material with the order of training in the air.

For example, the student does not need to understand the gyroscopic attitude instruments until later in the course; however, he needs basic aeronautics before or concurrent with his early flights and navigation prior to his cross-country instruction.

Maximum benefit to the student in the air and maximum motivation for the student in the classroom may be obtained through the coordination of the two types of instruction.

OUTLINE

Lesson

1. Dual - Preflight demonstrations
2. Dual - Review; straight and level; demonstrations
3. Dual - Coordination exercises; slow flight; stalls
4. Dual - Stall recovery; traffic pattern
5. Dual - Takeoffs and landings; airspeed control
6. Dual - Review; takeoffs and landings; forced landings
7. Dual - Crosswind takeoffs and landings; use of flaps
8. Dual & 1st Solo - Turns about a point
9. Dual & Solo - Review pre-solo flight maneuvers
10. Dual - Precision 180° and 360° approaches; magnetic compass
11. Solo - Practice prescribed maneuvers
12. Dual & Solo - Demonstrate ability; prepare for cross country
13. Dual Cross Country - Plotting; VOR; Communications
14. Solo - Practice; navigational radio
15. Dual Cross Country - 3 hrs, triangular course
16. Dual - Cross Country emergencies, weather
17. Solo - Cross Country; 2 unfamiliar airports; flight plan
18. Dual - Night flight, directed performance
19. Solo - Cross Country - 100 mile legs, airway radio aids
20. Dual & Solo - Prepare for Private Flight Test
21. Solo - Cross Country, 4 hours.
22. Solo - Practice; coordination
23. Solo - Ground reference maneuvers; maximum climbs
24. Dual & Solo - Instructor's evaluation
25. Solo - Practice towards flight test

(Continued)

FLIGHT TRAINING

Lesson

26. Solo - Practice cross country procedures
27. Solo - Practice Maneuvers for Private Flight Test
28. Dual - Instructor's Evaluation for Flight Test
29. Dual & Solo - Correct deficiencies noted in Lesson 28
30. Dual - Prepare Pilot Flight Test by instructor

Use Flight Instructor's Handbook, AC 61-16, pages 81-93 inclusive.

LESSONS:

LESSON 1. DUAL FLIGHT

The first lesson consists of familiarization with the airplane and its operating procedures, the sensations of flight, and the local flight areas, and the use of the flight controls and instruments. A short out-and-back cross-country flight to a nearby airport is often effective in stimulating the new student's interest.

1. *Airplane familiarization*	Ground instruction.
Preflight inspection. Cockpit familiarization. The airplane flight manual.	
2. *Starting the engine*	Demonstration.
3. *Radio communications*	Do.
4. *Taxiing*	Demonstration or directed performance.
5. *Pretakeoff check*	Demonstration with student participation.
6. *Takeoff, traffic pattern, and climbout*	Demonstration.
7. *Familiarization flight*	Demonstration, and performance by student as feasible (Visual and Instrument References).
Control effects and usage. Flight area familiarization. Straight and level flight. Pitch and bank control. Approach, traffic pattern, landing, and parking.	
8. *Postflight discussion.*	
9. *Preview of next lesson.*	
Straight and level, climbs, turns, and descents. Slow flight and power-off stalls.	

LESSON 2. DUAL FLIGHT

During his second lesson, the student should learn to perform the four basic flight maneuvers (straight and level, climbs, turns, and descents) without assistance, and slow flight and power-off stalls under the direction of his instructor.

1. *Preflight discussion*	Review, as required.
2. *Starting engine*	Directed practice.
3. *Radio communication procedures*	Do.
4. *Taxiing*	With close surveillance by instructor.
5. *Pretakeoff check*	Directed performance.
6. *Takeoff and traffic pattern*	Demonstration, with student follow-through.
7. *Climbing turns*	Demonstration and student performance (VR and IR).

8.	*Straight and level*	Directed practice (VR and IR).
9.	*Medium turns*	Demonstration and student performance (VR and IR).
10.	*Slow flight*	Do.
11.	*Power-off stalls*	Do.
12.	*Steep turns*	Demonstration only.
13.	*Confidence maneuvers*	Demonstration and practice.
14.	*Descents and gliding turns*	Demonstration and student performance (VR and IR).
15.	*Approach, traffic pattern, and landing*	Demonstration, with student follow-through.
16.	*Taxiing and parking*	Directed performance.
17.	*Postflight discussion.*	
18.	*Preview of next lesson.* Takeoff, traffic pattern, and departure. Coordination exercises.	

LESSON 3. DUAL FLIGHT

During this lesson, the student should attain reasonable proficiency in the performance of the four basic flight maneuvers, and learn to perform without assistance slow flight, power-off stalls, and simple coordination exercises.

On this lesson, and hereafter, the student should be responsible for the preflight inspection, starting, radio communications, taxiing, and parking without direction from the instructor, except in unusual circumstances or in new, unfamiliar situations.

1.	*Preflight discussion*	Instruction and review.
2.	*Takeoff*	Student performs, with instructor follow-through.
3.	*Traffic pattern and departure*	Directed performance.
4.	*Climbs and climbing turns*	Directed practice (VR and IR).
5.	*Level-off from climbs and glides*	Do.
6.	*Straight and level, medium turns*	Practice (VR and IR).
7.	*Coordination exercises*	Demonstration and practice.
8.	*Speed changes in level flight*	Directed practice (VR and IR).
9.	*Slow flight and power-off stalls*	Practice (VR and IR).
10.	*Glides and gliding turns*	Do.
11.	*Airport approach and traffic pattern*	Directed performance.
12.	*Postflight discussion.*	
13.	*Preview of next lesson.* Power stalls. Ground reference maneuvers. Landing approaches. Elementary forced landings.	

LESSON 4. DUAL FLIGHT

During this lesson, the student should achieve the ability to recognize and recover smoothly from stalls without direction, fly prescribed patterns by ground references, and execute a traffic pattern and landing approach with the instructor's direction.

1.	*Preflight discussion*	Instruction and review.
2.	*Takeoff, traffic pattern, and departure*	Directed performance.
3.	*Straight and level, turns, climbs, and descents.*	Review and practice (VR and IR).
4.	*Slow flight and stalls*	Practice (VR and IR).
5.	*Turns to headings*	Directed performance (VR and IR).
6.	*Ground reference maneuvers* Following road or stream. S turns across a road. Rectangular course.	Directed practice.
7.	*Elementary forced landing*	Demonstration and student performance.
8.	*Traffic pattern and landing approach*	Directed performance.
9.	*Postflight discussion.*	
10.	*Preview of next lesson.* Takeoffs and landings. Emergency procedures.	

LESSON 5. DUAL FLIGHT

Lesson 5 is a review of the flight maneuvers and procedures already covered in preparation for serious work on takeoffs and landings and on traffic pattern operations. Reasonable proficiency in all coordination, airspeed control, and ground reference maneuvers should be achieved before takeoff and landing practice is initiated.

1.	*Preflight discussion*	Instruction and review.
2.	*Preflight operations*	Demonstration by student.
3.	*Coordination maneuvers*	Demonstration by student (VR and IR).
4.	*Slow flight and stalls*	Student demonstration (VR and IR).
5.	*Ground reference maneuvers*	Do.
6.	*Emergency procedures*	Demonstrations, and performance by student.
7.	*Takeoff and landing*	Directed performance.
8.	*Traffic pattern observance, entry, and departure.*	Directed practice.
9.	*Postflight discussion.*	
10.	*Preview of next lesson.* Takeoffs and landings. Steep turns. Accelerated stalls.	

LESSON 6. DUAL FLIGHT

Concentrated practice of takeoffs and landings should begin with this lesson. To provide an occasional change of pace, reviews of previously introduced flight maneuvers should be practiced, and steep turns and accelerated stalls should be introduced.

By the completion of this lesson, the student should be able to make directed takeoffs and landings without assistance on the controls. Simulated forced landings should be introduced at unannounced points during this lesson, and hereafter,

1.	*Preflight discussion*	Instruction and review.
2.	*Takeoffs and landings*	Directed practice.
3.	*Traffic pattern operations*	Practice.

4.	*Steep turns*	Student performance (VR and IR).
5.	*Accelerated stalls*	Demonstration and student performance.
6.	*Postflight discussion.*	
7.	*Preview of next lesson.* Slips. Crosswind takeoffs and landings. Balked takeoffs and emergency go-arounds.	

LESSON 7. DUAL FLIGHT

Crosswind takeoffs and landings, as well as slips, should be added to the practice of normal takeoffs and landings. At the completion of this lesson, the student should be able to make unassisted takeoffs and landings, and fly an accurate traffic pattern.

Short reviews of previously covered maneuvers should be introduced occasionally as a change of pace during takeoff and landing practice.

1.	*Preflight discussion*	Instruction and review.
2.	*Takeoffs and landings*	Practice.
3.	*Crosswind takeoffs and landings*	Demonstration and student performance.
4.	*Slips*	Do.
5.	*Use of flaps for takeoffs*	Do.
6.	*Balked takeoffs*	Directed performance.
7.	*Emergency go-arounds*	Do.
8.	*Review of earlier maneuvers*	Practice (VR and IR).
9.	*Postflight discussion.*	
10.	*Preview of next lesson.* Turns about a point. Cross-control stalls. Maximum performance takeoffs.	

LESSON 8. DUAL AND FIRST SOLO FLIGHT

At the completion of the dual portion of this lesson, the student should have achieved reasonable proficiency in all the flight training maneuvers he has received, be able to make safe takeoffs and landings consistently without assistance or direction, and recover from poor approaches and bad bounces. He should have demonstrated the ability to solve all ordinary problems to be encountered on local flights.

Three solo flights are recommended during the first solo period, if his observed performance is satisfactory, to build the student's confidence. No further solo flights should be authorized until after a rest period and further dual review of basic maneuvers.

1.	*Preflight discussion*	Instruction and review.
2.	*Takeoffs and landings*	Practice.
3.	*Slow flight and stalls*	Review (VR and IR).
4.	*Coordination exercises*	Do.
5.	*Emergencies*	Review.
6.	*Turns about a point*	Directed performance.
7.	*Cross-control stalls*	Demonstration.

8. *Maximum performance takeoff*	Demonstrations.
9. *The solo flight*	Instructor observes.
10. *Postflight discussion.*	
11. *Preview of next lesson.*	
Maximum performance climbs.	
Precision turns.	

LESSON 9. DUAL AND SOLO FLIGHT

The introduction of and instruction in additional maneuvers and procedures should continue after the first solo flight, and progressively higher standards of performance should be required for maneuvers previously learned.

This lesson should consist of a review of presolo flight maneuvers, and the introduction and practice of maximum performance takeoffs and climbs and precision turns. Four or five solo flights in the traffic pattern should be permitted, depending on the student's performance.

1. *Preflight discussion*	Instruction and review.
2. *Review of presolo maneuvers*	Practice (VR and IR).
3. *Maximum performance takeoffs and climbs.*	Directed practice.
4. *Precision turns*	Directed practice (VR and IR).
5. *Takeoffs and landings*	Dual and solo practice.
6. *Postflight discussion.*	
7. *Preview of next lesson.*	
Precision approaches.	
Use of the compass.	
Area checkout.	

LESSON 10. DUAL FLIGHT

This lesson contains a refamiliarization with local practice areas and a review of flight maneuvers in preparation for local solo practice flights. Precision 180° and 360° approaches, and the use of the magnetic compass should be introduced. At the completion of the lesson the student should be ready for local solo flights in assigned practice areas.

1. *Preflight discussion*	Instruction and review.
2. *Flight maneuvers*	Practice (VR and IR).
3. *Recovery from unusual attitudes*	Directed performance (IR).
4. *Ground reference maneuvers*	Review.
5. *Slow flight and stalls*	Review (VR and IR).
6. *Precision Approaches*	Demonstration and student performance.
7. *Use of magnetic compass*	Directed performance (VR and IR).
8. *Takeoffs and landings*	Practice.
9. *Postflight discussion.*	
0. *Preview of next lesson.*	
First solo flight outside traffic pattern.	
Elementary flight maneuvers.	
Takeoffs and landings.	

LESSON 11. SOLO FLIGHT

This is the first lesson during which the student is permitted to solo without previous dual checkout, provided conditions permit it. It should include the practice of specified maneuvers and procedures within assigned practice areas, and normal takeoffs and landings. At its completion, the student should have confidence and a sense of ease in flight which will make him receptive to new areas of instruction.

1. *Preflight discussion*	Assignment of maneuvers and areas.
2. *Flight maneuvers and procedures*	Solo practice, as assigned.
3. *Takeoffs and landings*	Solo practice.
4. *Postflight discussion.*	
5. *Preview of next lesson.* Review of flight procedures and maneuvers. Stalls from critical flight situations.	

LESSON 12. DUAL AND SOLO FLIGHT

This lesson should be equally divided, approximately, between dual and solo flight. At its completion, the student should have demonstrated his ability to maneuver and land the airplane confidently without direction or assistance, and be prepared for cross-country instruction.

1. *Preflight discussion*	Instruction and review.
2. *Slow flight and stalls*	Review (VR and IR).
3. *Stalls from critical flight situations*	Demonstration and student performance.
4. *Coordination maneuvers*	Review (VR and IR).
5. *Ground reference maneuvers*	Review.
6. *Crosswind takeoffs and landings*	Practice.
7. *Takeoffs and landings*	Practice.
8. *Solo practice*	As directed.
9. *Postflight discussion.*	
10. *Preview of next lesson.* Assignment: Procure materials for cross-country flight. Plot and prepare cross-country flight log.	

LESSON 13. DUAL CROSS-COUNTRY FLIGHT

This lesson should be equally divided, approximately, between ground instruction and dual flight instruction. Flight preparation should be thorough, and each step carefully explained to the student. The flight should consist of an out-and-back flight over a 1-hour course, approximately.

1. *Preflight preparation*	Ground instruction—course plotting and preparing cross-country log sheet.
2. *Cross-country flying*	Directed performance (VR and IR).

Pilotage. Dead reckoning. Tracking VOR radial.	
3. *Cross-country emergencies*	Directed practice.
4. *Unfamiliar airport procedures*	Directed performance.
5. *Use of radio for enroute communications*	Do.
6. *Postflight discussion.*	
7. *Preview of next lesson.* Local solo practice flight.	

LESSON 14. SOLO FLIGHT

This lesson includes solo practice on flight maneuvers, takeoffs and landings, and on the use of navigational radio.

1. *Preflight discussion*	Assignment of procedures and practice areas.
2. *Takeoffs and landings*	Solo practice.
3. *Crosswind takeoffs and landings, slips*	Solo practice, as practicable.
4. *Slow flight and stalls*	Solo practice.
5. *Tracking to and from VOR range (advise flight service station).*	Do.
6. *Steep turns*	Do.
7. *Flight maneuvers specifically assigned by instructor.*	
8. *Preview of next lesson.* Dual cross-country flight using radio aids.	

LESSON 15. DUAL CROSS-COUNTRY FLIGHT

This is a cross-country flight over a triangular flight requiring approximately 3 hours of flight time, using pilotage, dead reckoning, and VOR ranges. At the completion of this lesson, the student should be prepared for VFR navigation over strange courses, and have the ability to cope with common cross-country emergencies.

1. *Preflight discussion*	Flight planning and preparation.
2. *VFR navigation* Pilotage. Dead reckoning. Use of radio aids.	Practice.
3. *Lost procedures*	Directed performance.
4. *Simulated inadvertent encounter with adverse weather conditions.*	Directed practice (VR and IR).
5. *Unfamiliar airport procedures*	Practice.
6. *Use of radio for enroute communications*	Do.
7. *Cross-country emergencies*	Do.
8. *Postflight discussion.*	
9. *Preview of next lesson.* Short- and soft-field takeoffs and landings. Emergency radio assistance (DF and Radar).	

LESSON 16. DUAL FLIGHT

This lesson concentrates on procedures appropriate to possible cross-country flight emergencies in preparation for extended solo cross-country flights. At lesson completion, the student should be competent to cope with common navigational and weather emergencies encountered on solo cross-country flights.

1.	*Preflight discussion*	Instruction and review.
2.	*Short-field takeoffs and landings*	Demonstration and practice.
3.	*Soft-field takeoffs and landings*	Do.
4.	*Slips and crosswind takeoffs and landings* (if practicable).	Directed practice.
5.	*Flight maneuvers, including steep turns*	Review (VR and IR).
6.	*Slow flight and stalls*	Do.
7.	*180° and 360° gliding approaches*	Directed practice.
8.	*Obtaining assistance by radio* (DF and radar steers, orientation by terrain features).	Directed performance (Make prior arrangement with ATS facility).
9.	*Postflight discussion.*	
10.	*Preview of next lesson.*	

Solo cross-country flight.

Assignment:

Prepare materials.

Prepare flight log.

LESSON 17. SOLO CROSS-COUNTRY FLIGHT

This solo cross-country flight should be over a relatively simple course with landings at two or more unfamiliar airports, preferably at least one with a control tower. A VFR flight plan should be filed when feasible, and flight following service should be requested.

1.	*Preflight discussion*	Approval of flight plan and weather analysis.
2.	*VFR navigation.*	
3.	*Unfamiliar airport procedures.*	
4.	*Filing of flight plans.*	
5.	*Postflight discussion*	Critique on all unanticipated events and operations.
6.	*Preview of next lesson.*	

Dual night flight.

LESSON 18. DUAL NIGHT FLIGHT

This lesson familiarizes the student with the special considerations and problems characteristic of flight at night. Solo flights in the traffic pattern may be permitted at the instructor's discretion. It is recommended that the period start in twilight, so that the student has experience in the transition from daylight to night flight conditions.

1.	*Preflight discussion*	Instruction and review.
2.	*Differences in visual references available at night.*	Demonstration.
3.	*Takeoff and departure alignment techniques.*	Directed performance.

4. *Power approach and landings*	Do.
5. *Use of landing lights*	Do.
6. *Interpretation of aircraft and obstruction lights.*	Directed Practice.
7. *Flight maneuvers over dark areas* (when feasible).	Do.
8. *Postflight discussion.*	
9. *Preview of next lesson.*	

Solo cross-country flight.
Assignment:
Procure necessary equipment.
Prepare flight log.

LESSON 19. SOLO CROSS-COUNTRY FLIGHT*

This solo cross-country flight should be planned to meet the private pilot certification requirement for a landing at an airport at least 100 miles from the point of departure. At least one leg should be flown on airways using radio aids, under a VFR flight plan, and flight-following service.

1. *Preflight discussion*	Instructor's approval of flight log and weather analysis.
2. *Filing and closing of flight plan.*	
3. *VFR navigation.*	
4. *Enroute radio communications.*	
5. *Unfamliar airport procedures.*	
6. *Servicing airplane.*	
7. *Postflight discussion*	Critique of any unanticipated incidents.
8. *Preview of next lesson.*	

Review of flight maneuvers.
Emphasis of precision on all maneuvers.

LESSON 20. DUAL AND SOLO FLIGHT

Active preparation for the private pilot flight test begins with this lesson. The FAA *Private Pilot Flight Test Guide* should be used for guidance on the procedures and standards to be applied to all flight maneuvers. At the completion of this lesson, the student should be prepared for solo practice on the correct performance of flight test maneuvers.

1. *Preflight discussion*	Flight test standards and review.
2. *Slow flight and stalls*	Directed (VR and IR) and solo (VR only) practice.
3. *Medium turns to headings*	Do.
4. *720° turns about a point*	Directed and solo practice.
5. *Normal and crosswind takeoffs and landings.*	Do.
6. *Full stall landings, or wheel landings in tailwheel airplanes.*	Directed practice.

---

* This lesson may be switched with Lesson No. 21, when required by weather conditions or other special circumstances.

7. *Recovery from unusual attitudes* ———— Directed practice (IR only).
8. *Postflight discussion.*
9. *Preview of next lesson.*
    Solo cross-country flight.
    Assignment:
        Provide necessary equipment.
        Prepare flight log.

LESSON 21. SOLO CROSS-COUNTRY FLIGHT*

This lesson provides additional cross-country experience, with emphasis on unfamiliar airport procedures. A 4-hour cross-country flight, or series of flights, should be arranged so as to include as many airports as practicable. At the completion of this flight the student should be competent to make VFR cross-country flights at his own responsibility.

1. *Preflight discussion* ———— Instructor's approval of flight plan and weather analysis.
2. *VFR navigation.*
3. *Unfamiliar airport procedures.*
4. *Radio communications.*
5. *Postflight discussion* ———— Critique of unanticipated occurrences.
6. *Preview of next lesson.*
    Local practice flight.

LESSON 22. SOLO FLIGHT

This lesson provides solo practice to develop precision in the performance of the flight maneuvers required for a private pilot certificate. It is suggested that emphasis be directed to coordination and to airspeed control maneuvers.

1. *Preflight discussion* ———— Assignment of maneuvers and practice areas.
2. *Airspeed control maneuvers, including stalls.*
3. *Coordination maneuvers, including turns to headings and steep turns.*
4. *Other maneuvers as directed by the instructor.*
5. *Postflight discussion.*
6. *Preview of next lesson.*
    Local solo practice flight.

LESSON 23. SOLO FLIGHT

This lesson should include solo practice of ground reference maneuvers, maximum climbs, and traffic pattern procedures. At the completion of this lesson, the student should be satisfied that he can perform his "air work" to a standard acceptable for a private pilot flight test.

---

* This lesson may be switched with Lesson No. 19 when required by weather conditions or other special situations.

1. *Preflight discussion*	Assignment of maneuvers and practice areas.
2. *Ground reference maneuvers.*	
3. *Coordination maneuvers*	Review only.
4. *Airspeed control maneuvers*	Do.
5. *Maximum performance climbs.*	
6. *Traffic pattern entries and departures.*	
7. *Normal and crosswind takeoffs and landings.*	As incident to traffic pattern practice.
8. *Maneuvers specifically assigned by instructor.*	
9. *Postflight discussion.*	
10. *Preview of next lesson.*	

Instructor's review of air work.
Solo practice as directed.

LESSON 24. DUAL AND SOLO FLIGHT

This lesson consists of the instructor's evaluation of the flight maneuvers practiced during the previous two lessons, and directed solo practice as needed. At the completion of this lesson, the student's performance of his "air work" should be at an acceptable level for the private pilot flight test.

1. *Preflight discussion*	Instruction and review.
2. *Coordination maneuvers*	Review and evaluation (VR and IR).
3. *Recovery from unusual attitudes*	Evaluation (IR only).
4. *Ground reference maneuvers*	Review and evaluation.
5. *Airspeed control maneuvers*	Review and evaluation (VR and IR).
6. *Traffic patterns*	Review and evaluation.
7. *Postflight discussion.*	
8. *Preview of next lesson.*	

Solo practice flight.
Takeoffs and landings.

LESSON 25. SOLO FLIGHT

During this lesson, the student should practice to achieve the standard of performance required by the private pilot flight test on special types of takeoffs and landings.

1. *Preflight discussion*	Assignment of maneuvers and practice areas.
2. *Short-field takeoffs and landings.*	
3. *Soft-field takeoffs and landings.*	
4. *Slips, and crosswind takeoffs and landings.*	
5. *Power approaches and full stall landings.*	
6. *Wheel landings if tailwheel airplane is used.*	
7. *Other maneuvers specifically assigned by instructor.*	
8. *Postflight discussion.*	
9. *Preview of next lesson.*	

Solo practice period.
Review of cross-country procedures.

LESSON 26. SOLO FLIGHT

During this lesson, the student should practice the cross-country flying procedures required during the private pilot flight test.

1. *Preflight discussion*	Assignment of procedures and practice areas.
2. *Pilotage and map reading.*	
3. *Time, speed, and distance computations between checkpoints.*	
4. *Tracking to and from a VOR station.*	
5. *Plotting VOR cross-bearings.*	
6. *Plotting alternate courses in flight.*	
7. *Other operations specifically assigned by instructor.*	
8. *Postflight discussion.*	
9. *Preview of next lesson.* Solo practice period. Private flight-test operations and procedures.	

LESSON 27. SOLO FLIGHT

During this lesson, the student should practice for the first time the performance of all the maneuvers and procedures included in the private pilot flight test. (No simulated instrument operation shall be included). Upon completion, the student should feel confident that he can perform all required maneuvers to the standard required for a private pilot certificate.

1. *Preflight discussion*	Review and practice area assignment.
2. *Private pilot flight test maneuvers and procedures.*	Solo practice.
3. *Preview of next lesson.* Instructor's evaluation of test performance.	

LESSON 28. DUAL FLIGHT

This lesson consists of the instructor's first evaluation of his student's performance of the complete private pilot flight test. Any deficiencies should be carefully noted for discussion at the end of the lesson and correction in the next lesson.

1. *Preflight discussion*	Statement of objective.
2. *Private pilot flight test*	Evaluation by instructor.
3. *Postflight discussion*	A thorough review of the student's deficiencies, and a full explanation of the appropriate corrections.
4. *Preview of next lesson.* Dual and solo practice on deficiencies.	

LESSON 29. DUAL AND SOLO FLIGHT

During this lesson the instructor seeks to correct any deficiencies discovered in the student's performance of the private pilot flight test maneuvers. At the completion of this lesson, the student should be ready for the check ride for the instructor's recommendation for the private pilot flight test.

1. *Preflight discussion*	Review and instruction.
2. *Flight-test maneuvers*	Review and instruction as necessary.
3. *Flight-test maneuvers*	Solo practice as assigned.
4. *Postflight discussion.*	
5. *Preview of next lesson.* Flight instructor's check for his recommendation of the student for his official private pilot flight test by an FAA inspector or designated pilot examiner.	

LESSON 30. DUAL FLIGHT

This lesson should consist of the private pilot flight test conducted by the instructor exactly as such tests are conducted by inspectors and examiners. The student should be able to perform all required procedures and maneuvers in accordance with the *Private Pilot Flight Test Guide.*

1. *Preflight discussion*	Phase I of the private pilot flight test.
2. *Private Pilot Flight Test*	Evaluated by the flight instructor.
3. *Postflight discussion*	Critique of overall performance.

Note: Before signing a flight-test recommendation for his student, it is the responsibility of the flight instructor to see that he meets all of the flight experience requirements for a private pilot certificate, including the total flight time, dual instruction, solo-flight time, cross-country, and instruction in the control of an airplane by reference to instruments.

FLIGHT ASSOCIATED ACTIVITIES
CHEROKEE 140 CHECKLIST

STARTING

Pre-Start

Seat belts fastened
Fuel - fullest tank
Prime as necessary
Master switch "ON"
Fuel pump "ON"
Fuel Pressure
Parking brake set
Ignition"L"
Carb. heat "COLD"
Throttle cracked
Mixture rich
"PROP CLEAR"

Start and Warm-Up

RPM 1000 - 1200
Ignition "BOTH"
Oil Pressure within 30 seconds
Fuel pump "OFF"
Radio "ON"
Lights "ON" as necessary

TAXI

Taxi clearance
Test brakes
Test gyros
Test localizer and VOT

PRE TAKE-OFF

Parking brake set
Flight controls
Flaps checked and set
Set directional gyro
Set Art. Horizon
Set altimeter record error
Set OMNI and OBS on first leg of
    flight
Check other instruments
Trim "NEUTRAL"
RPM 1800

Carb. heat - RPM drop
Mags - 125 RPM maximum
Suction
Mixture "RICH"
RPM 1000
Fuel pump on

Instruments in "GREEN"
Window closed
Door latched
RADIO to "TOWER"

TAKE-OFF

Full power rotate at 60
Depress toe brakes

Fuel pump "OFF"

CLIMB

Carb. heat "COLD"
Flaps - "UP" or 25° for best angle

Airspeed - 74 best angle
85 best rate - 100 cruise

CLIMB (Con't.)

Mixture "RICH" below 5,000 maximum
RPM above 5,000 feet

CRUISE

Carb. heat "COLD"
Fuel as desired Lean for drop

BEWARE OF TOO LEAN A MIXTURE - THIS RUINS GOOD ENGINES IN A HURRY

LET DOWN

Carb. heat "HOT"
Mixture "RICH"

PRE-LANDING

Carb. heat "HOT"
Mixture "RICH"
Fuel Pump "ON"
Fuel on fullest tank
Flaps - as needed

POST-LANDING FULL STOP

Flaps "UP"
Carb. heat "COLD"
Fuel pump "OFF"

AFTER EACH PRACTICE LANDING AND PRIOR TO TAKE-OFF RE-CHECK:

Flaps "UP" or 25° for best angle
Trim "NEUTRAL"
Carb. heat "COLD"
Mixture "RICH"
Window closed
Door latched

POST LANDING TOUCH-AND-GO

Flaps "UP"
Carb. heat "COLD"
Trim "NEUTRAL"
Fuel pump "ON"

SHUT-DOWN AND PARK

Radio "OFF"
Lights "OFF"
Ignition check for "OFF"
Mixture "OFF"
Ignition "OFF"
Master switch "OFF"

EMERGENCY

Carburetor heat first
Check fuel selector
Fuel boost pump "ON"
Take your time, don't get excited
Look around for a good emergency field

RESOURCES

Reference Books and Information:

Aircraft Owners and Pilots Association (AOPA), 4650 East-West Highway, Bethesda, Maryland, will respond to requests for flight training information.

Crystal Shamrock, Inc., Gold Seal Training Curriculum, "Private Flight Training Syllabus." Write to Crystal Shamrock, Inc., 6000 Douglas Drive North, Minneapolis, Minnesota 55429.

*Federal Aviation Administration, FAA Advisory Circulars:

00-2	"Advisory Circular Checklist," (Latest revision)
61-3B	"Flight Test Guide - Private Pilot - Airplane - Single Engine," (4-2-68). ($0.20, GPO).
61-16	*Flight Instructor's Handbook* (1-19-65). ($1.25 GPO)
61-32	*Private Pilot Written Examination Guide*, (8-15-67). ($1.75 GPO) GPO).
61-35A	"Gold Seal Flight Instructor Certificate," (2-11-69)
90-8	"Radio Identification of Student Pilots," (8-15-63).
90-34	"Accidents Resulting from Wheelbarrowing in Tricycle Gear Equipped Aircraft," (2-27-68)
90-37	"Flight Operations Near Airports," (6-19-68).
90-42	"Traffic Advisory Practices at Non-tower Airports," (12-9-68).
140-2	"List of Certificated Pilot Flight and Ground Schools," (Latest revision)

Federal Aviation Administration, *Directory of Aviation Medical Examiners* (Annual). Write FAA, Distribution Unit, TAD 484.3, Washington, D.C. 20590.

*See page 244 for address for obtaining copies.

Other Aids:

Sanderson Films, Inc., *Flight Maneuvers Course* and *Pre-Flight Facts*. Include filmstrips, records, and course manuals. Write to Sanderson Films, Inc., P.O.Box 13121, Wichita, Kansas 67213.

Federal Aviation Administration, "FLYING CLUBS", FA-705, 28 min. 16mm. Color and sound.

TO THE TEACHER

The following is a list of general interest films recommended for use in the Aero Science Course. Due to the large number of films, not all of them can be used during one year. However, selection can be made and a list suited to the personal needs of the teacher and students may be compiled.

It is assumed that films will be used to supplement and not to replace the lecture, text, or teacher. Films can be a definite adjunct to the course in Aero Science, but too many films detract from the spontaneity of learning.

A list of film producers and distributors is also included. All films are on a free loan basis. Reservations should be made well in advance of the intended date of showing.

General Interest Films:

Ace In the Hole (SFP 1094)(minuteman)- 15 min. (C)	USAF
A-4-D Sky Hawk - 20 min.	Douglas
Carrier Action off Korea (MN-9272)	USN
Copters In Combat - 12½ min. (C)	Sikorsky
DC-8 Jet Mainliner (12C)	Douglas
Eclipse of the Quiet Sun - 27 min.	Douglas
Exploring the High Frontier (28C)	Douglas
F4-D Spearhead of Defense - 12 min.	Douglas
The F-111 Story - 21 min. (C)	General Dynamics
Jet Bombers Go To Sea - 13 min.	Douglas
New Wings for the Navy - 11 min.	Douglas
Nike for the Defense of America - 12 min.	Douglas
Northliner - 25 min. (C)	North Central Airlines
One Eye on the Instruments - 20 min.	FAA
Pacific Missle Range (MN8879)-14½ min.	USN
Search Operations (SFP 1039)-28½ min.	USAF
South Pole City - 27 min.	Douglas
Song of the Clouds - 36 min. Color	Shell
The Best Investment Ever Made - 25 min.	FAA
The Long Right Arm - 30 min.	Douglas
To Save A Life - 20 min.	FAA
United 6534 - 30 min. (C)	UAL
Up and Over - 12 min. (C)	Sikorsky
Wings at Work - 28 min. (C)	Lockheed-Georgia Co.
Wings for Adventure - 26½ min. (C)	UAL
Wings for Industry - 27 min. (C)	UAL
Year of the Polaris - 55 min.	USN

LIST OF FILM PRODUCERS AND DISTRIBUTORS

Beech Aircraft Corporation
Wichita, Kansas 67201
Attn: Aviation Education Dept.

Bell Telephone - Contact your
local telephone business office.

Boeing Company
News Bureau, M.S. 16-41 (Film
Editor), Seattle, Wash. 98124

California Dept. of Aeronautics
Sacramento Municipal Airport
Sacramento, California 95822
Attn: Air Safety and Education

Cessna Aircraft Company
P. O. Box 1521
Wichita, Kansas 67201
Attn: Director, Public Relations

Douglas Aircraft Company, Inc.
Film & Television Communications,
G-83
3000 Ocean Park Boulevard
Santa Monica, California 90406

**Federal Aviation Administration
Film Library, AC-921
P. O. Box 25082
Oklahoma City, Oklahoma 73125

General Dynamics
Assistant to the President
Fort Worth Division
P. O. Box 748
Fort Worth, Texas 76101

General Motors Corporation
Public Relations Staff, Film
Library
General Motors Building
Detroit, Michigan 48202

Goodyear Tire and Rubber Company
Public Relations Film Library
1144 East Market Street
Akron, Ohio 44316

Lockheed-Georgia Company
Motion Picture Film Library
Zone 30, B-2 Building
Marietta, Georgia 30061

Los Angeles Department of Airports
One World Way
Los Angeles, California 90009
Attn: Public Relations Dept.

Martin Company
Film, Mail #1020
P. O. Box 179
Denver, Colorado 80201

McGraw-Hill Book Company
327 West 41st Street
New York, N.Y. 10036
Attn: Text-Film Division

*Modern Talking Picture Service
1212 Avenue of the Americas
New York, N.Y. 10036

**National Aeronautics and Space
Administration - NASA publications
and film libraries.

If you live in:	Write to:
Alaska, Idaho, Montana, Northern Calif. (North of Los Angeles Metropolitan area), Oregon, Washington, Wyoming.	NASA Ames Research Center, Public Affairs Office,Maffett Field, Calif., 94035
Connecticut,Maine, Massachusetts, New Hampshire, New York Rhode Island, Vermont	NASA Electronics Research Center, Educational Programs Office, Cambridge, Mass. 02139
Alabama,Arkansas, Louisiana, Mississippi, Missouri, Tennessee	NASA George C. Marshall Space Flight Center, Public Affairs Office, Space Flight Center, 35812

*Regional and local offices of these organizations also have films.

**FAA and NASA film catalogs are available upon request.

LIST OF FILM PRODUCERS AND DISTRIBUTORS

If you live in:	Write to:
Delaware, District of Columbia, Maryland, New Jersey, Pennsylvania, West Virginia	NASA Goddard Space Flight Center Photographic Branch Code 253, Greenbelt, Maryland 20771
Florida, Georgia, Puerto Rico, Virgin Islands	NASA John F. Kennedy Space Center, Code SOP 323, Kennedy Space Center, Florida 32899
Kentucky, North Carolina, South Carolina, Virginia	NASA Langley Research Center, Langley Sta., Public Affairs Office, Mail Stop 154, Hampton, Virginia 23365
Illinois, Indiana, Iowa, Michigan, Minnesota, Ohio, Wisconsin	NASA Lewis Research Center, Office of Educational Services 21,000 Brookpark Rd. Cleveland, Ohio 44135
Colorado, Kansas Nebraska, New Mexico, North Dakota, Oklahoma, South Dakota, Texas	NASA Manned Spacecraft Center, Public Affairs Office, AP-2, Houston, Texas 77058
Arizona, Hawaii, Nevada, Southern California (San Luis Obispo, Kings, Kern, Tulare, and Inyo Counties, and south), Utah	NASA Pasadena Office, 4800 Oak Grove Drive, Pasadena, Calif.91103
Canada	National Science Film Library, 1762 Carling Street, Ottawa 13, Ontario, Canada
All other foreign countries	NASA Headquarters Code FAD-2, Washington, D.C. 20546

North American Rockwell Corp.
International Airport
Los Angeles, California 90009
Attn: Film Library, Dept. 61
Public Relations Dept.

North Central Airlines, Inc.
6201 Thirty-Fourth Avenue South
Minneapolis, Minnesota 55450
Attn: Public Relations Dept.

Northwest Airlines, Inc.
Minneapolis-St.Paul International Airport
St. Paul, Minnesota 55111
Attn: Public Relations Dept.

*Piper Aircraft Corporation
Lockhaven, Pennsylvania 17745
Attn: Air Science Education Department

Sanderson Films, Inc.
P. O. Box 13121
Wichita, Kansas 67213

Shell Oil Company
Film Library
450 N. Meridian Street
Indianapolis, Indiana 46204

Sikorsky Aircraft Company
Division, United Aircraft Co.,
Stratford, Connecticut 06497
Attn: Public Relations Manager

TRW Systems
Building 60T, Room 3090
1 Space Park
Redondo Beach, Calif. 90278
Attn: Film Services

*United Air Lines
P. O. Box 66100
O'Hare International Airport
Chicago, Illinois 60666

U. S. Air Force
USAF Central Audio Visual Library
Audio Visual Center
Norton Air Force Base, Calif.92409

U. S. Navy - Address your request to the Commandant of the appropriate Navy District, Attention of the Assistant for Public Information.

If you live in:	Write to:
Maine, Massachusetts, New Hampshire, Rhode Island, Vermont	First Naval District 495 Summer Street Boston, Mass. 02110
Connecticut, New York, New Jersey (northern half)	Third Naval District 90 Church Street New York, N.Y. 10007
Pennsylvania, New Jersey (southern half), Ohio, Delaware	Fourth Naval District U. S. Naval Base Philadelphia,Penn. 19112
Maryland, Virginia, West Virginia, Kentucky	Fifth Naval District U.S. Naval Base Norfolk, Virginia 23511
North Carolina, South Carolina, Alabama, Mississippi, Georgia, Florida,Tennessee	Sixth Naval District U.S.Naval Base Charleston, South Carolina, 29403
Louisiana, Arkansas, Oklahoma, Texas, New Mexico	Eighth Naval District U.S.Naval Station New Orleans,Louisiana 70140
Michigan,Indiana, Illinois,Wisconsin Minnesota,Iowa, Missouri, North Dakota, South Dakota, Nebraska, Kansas,Colorado, Wyoming	Ninth Naval District U. S. Naval Training Center, Great Lakes Illinois 60088
Arizona, Southern California	Eleventh Naval District 937 North Harbor Dr. San Diego,Calif.92130
Utah, Nevada, Northern California	Twelfth Naval District Federal Office Building. San Francisco, Calif.94102
Washington, Oregon, Idaho, Montana	Thirteenth Naval District U.S.Naval Station Seattle, Washington 98119

U. S. Parachute Association
P. O. Box 109
Monterey, California 93940
Attn: Norman E. Heaton,
Executive Director

*Regional and local offices of these organizations also have films.

TO THE TEACHER

This unit is included solely for the purpose of encouraging the teacher to require selected reading of his aeronautical students. The list, as presented, represents all grades of difficulty and in no way should it be considered the ultimate in reading lists.

Outside reading can serve at least two purposes; one, to further acquaint the student with the aeronautical world, and, two, to bring to the student a degree of motivation to overcome the "chore" of reading.

It is further recommended that the teacher select his books to suit the needs and interests of his students and that each student be required to make a report on his reading.

Aireview, General View of Japanese Military Aircraft in the Pacific War, Tokyo: Kantosha Co., Ltd. Tokyo, Japan, 1956, 1958.

Aireview, German Military Aircraft in the Second World War, Tokyo: Kantosh, 1958, 1959.

Air Force, Space Weapons, Praeger, Frederick A. Inc., 111 4th Avenue, New York, New York 10003, 1959.

American Heritage, American Heritage, History of Flight, Simon and Schuster, 630 5th Avenue, New York, New York 10020, 1962.

Bernardo, Aviation in the Modern World, Dutton, E.P. and Co., Inc., 201 Park Avenue South, New York, New York 10003, 1960.

Bechdolt, Going Up, Abingdon Press, 201 8th Avenue South, Nashville, Tennesee 37202, 1948.

Benner, Couriers of the Sky, Knopf, Alfred A. Inc., 501 Madison Avenue, New York, New York 10022, 1952.

Boff, Boys' Book of Flying, Dutton, E.P. and Co., Inc., 201 Park Avenue South, New York, New York 10003, 1937.

Bridgeman, Lonely Sky, Holt, Rinehart and Winston, Inc., 383 Madison Avenue, New York, New York 10017, 1955.

Brophy, Air Force, Messner, Julian, Inc., One West 39th Street, New York, New York 10018, 1956.

Buchanan, Flying Years, Putman's, G.P., and Sons, 200 Madison Avenue, New York, New York 10016, 1953.

Caidin, Cross Country Flying, Dutton, E.P. and Co., 1961

Caidin, Test Pilot, Dutton, E.P. and Co., 1961.

Caidin, Thunderbirds!, Dutton, E.P. and Co., 1961.

Chapin, Why Men Can Fly, Reynal and Co., 221 East 49th Street, New York, New York 10017, 1943.

Carlisle, Modern Wonder Book of the Air, Holt, Rinehart and Winston, 1945.

Civil Air Regulations and Flight Standards for Pilots, Aero Publishers, 329 Aviation Road, Fallbrook, California 92028, 1961.

Clarke, Exploration of Space, Harper and Row Publishers, Elementary-High School Division, 2500 Crawford Avenue, Evanston, Illinois 60201, 1959.

Cochran, Stars at Noon, Little, Brown and Co., 34 Beacon Street, Boston, Massachusetts 02106, 1954.

READING LIST

Colby, Countdown; Story of Our Missile Bases, Coward-McCann, Inc., 200 Madison Avenue, New York, New York 10016, 1960.

Colby, Operation Watchdog, Coward-McCann, Inc., 1956.

Colby, Wings of Our Navy, Coward-McCann, Inc., 1952.

Cooke, Fighter Planes That Made History, Putnam's, 1958.

Coombs, Rockets, Missiles and Moons, Morrow, William and Co., 425 Park Avenue South, New York, New York, 10016, 1957.

Coombs, Survival in the Sky, Morrow, William and Co., 1956.

Davis, Through the Stratosphere, Macmillan Co., Sub. of Crowel Collier and Macmillan, 60 5th Avenue, New York, New York 10022, 1946.

Day, Glacier Pilot, Holt, Rinehart and Winston, 1957.

Dollfus, The Orion Book of Balloons, Orion Press, 150 East 35th Street, New York, New York 10016, 1961.

Earhart, Fun Of It, (Jr. Literary Guild) Doubleday and Co., Inc., 501 Franklin Avenue, Garden City, New York 11531, 1932.

Earhart, Last Flight, Harcourt, Brace and World, Inc., 757 3rd Avenue, New York, New York 10017, 1937.

Earhart, Soaring Wings, Harcourt, Brace and World, Inc., 1939.

Edmonds, They Fought With What They Had, Little, Brown and Co., 1951.

Engeman, U.S. Air Force Academy: Life of a Cadet, Lothrop, Lee and Shepard, 419 Park Avenue South, New York, New York 10016, New Ed., 1959.

Farley, U.S. Army Air Force Fighter Planes, Aero Publishers, 1957.

Fraser, Heroes of the Air, Crowell Collier and Macmillan, Inc., 1926.

Gaul, Complete Book of Space Travel, World Publishing Co., 2231 West 110th Street, Cleveland, Ohio 44102, 1956.

Glassman, Jump, Simon and Schuster, 1930.

Glines, Grand Old Lady: Story of DC-3, Pennington Trading Post, Freemont, Missouri 63941, 1959.

Grace, Visibility Unlimited, Longmans, Green and Co., Inc., 55 5th Avenue, New York, New York, 1950.

Green, Aircraft of the World, Hanover House Books, Doubleday Book Co., Inc., 1956.

Green, Famous Bombers of the Second World War, Doubleday Book Co., Inc., 1960.

Green, Famous Fighters of the Second World War, Doubleday Book Co., Inc., 1957.

Greenwood, Parachute, Dutton, E.P. and Co., Inc., 1964.

Gurney, Five Down and Glory; History of the American Air Ace, Putnam, 1958.

Gurney, Test Pilots, Watts, Franklin Inc., (Sub. of Grolier) 575 Lexington Avenue, New York, New York 10022, 1962.

Gubitz, Rocketship X-15, Messner, 1960.

Hailey, Arthur, Airport. Garden City, N.Y.: Doubleday, 1968.

Hall, 1000 Destroyed, Dallas: Morgan & Morgan, Inc. Publishers, 25 Main Street, Hastings-on-the-Hudson, New York 10706, 1946.

Heinmyller, Man's Fight to Fly, Funk and Wagnalls Co., 360 Lexington Avenue, New York, New York 10017, 1944.

Hitt, Jungle Pilot, Harper and Row, 1959.

Hubler, SAC: The Strategic Air Command, Duell, Sloan and Pearce, 60 East 42nd Street, New York, New York 10017, 1958.

Hyde, Flight Today and Tomorrow, McGraw-Hill Book Co., 330 West 42nd Street, New York, New York 10036, 1962.

Inks, Eight Bailed Out, Mortons Press, 721 Latham Square Building, Oakland, California 94612, 1954.

Johnson, Your Pilot's License, Crown Publishing, Inc., 419 Park Avenue South, New York, New York 10016, 1960.

Jones, U.S. Bombers B-1 - B-70, Aero Publishers, 1962.

Jordanoff, Flying and How To Do It, Grosset and Dunlap, Inc., 51 Madison Avenue, New York, New York 10010, 1940.

Jordanoff, Your Wings, Funk and Wagnalls, 1942.

Kettlekamp, Gliders, Morrow, 1961.

Landis, Air Force, From Civilian to Airman, Viking Press, Inc., 625 Madison Avenue, New York, New York 10022, 1958.

Land, Twenty Seconds to Live, Dutton, E.P. and Co., 1959.

READING LIST

Langewiesche, Flier's World, McGraw-Hill, 1951.

Langewiesche, Stick and Rudder, McGraw-Hill, 1944.

Lawson, Thirty Seconds Over Tokyo, Random House, Inc., 457 Madison Avenue, New York, New York 10022, 1943.

Lent, Air Patrol, Macmillan, 1942.

Lent, Bombardier, Macmillan, 1943.

Lent, Eight Hours to Solo, Macmillan, 1947.

Lent, Jet Pilot, Macmillan, 1958.

Lewellen, Jet Transports, Crowell Collier, 1955.

LeVier, Pilot, Harper and Row, 1954.

Ley, Rockets, Missiles and Space Travel, Viking Press, 1958.

Lindberg, Spirit of St. Louis, Scribner's, Charles & Sons, 597 5th Avenue New York, New York 10017, 1953.

Lindberg, North to the Orient, Harcourt, Brace and World, 1935.

Lundgren, Across the High Frontier, Morrow, 1955.

Mallan, Men, Rockets and Space Rats, Messner, 1961.

Masters, On the Wing; Pioneers of the Flying Age, Holt, Rinehart and Winston, 1934.

Menzel, Flying Saucers, Harvard University Press, Kittridge Hall, 79 Garden Street, Cambridge, Massachusetts 02138, 1953.

Mitchell, Memoirs of World War I, Random House, 1960.

Moore, First Five Million Miles, Harper and Row, 1955.

Morenus, Dew Line; Distant Early Warning, Rand-McNally and Co., Box 7600, Chicago, Illinois 60680, 1957.

Morris, Ceiling Unlimited, Macmillan, 1953.

Montross, Cavalry of the Sky, Harper and Row, 1954.

Munday, Captains of the Sky, Ronaid Press Co., 15 East 26th Street, New York, New York 10010, 1942.

Murchie, Song of the Sky, Houghton-Mifflin Co., 2 Park Street, Boston, Massachusetts 02107, 1954.

Murray, Sky Girl, Duell, 1953.

Newell, Express to the Stars, McGraw-Hill, 1961.

O'Berth, Man Into Space, Harper and Row, 1957.

Oughton, Aces, Putnam, 1960.

Piccard, Earth, Sky and Sea, Oxford Book Co., Inc., 71 5th Avenue, New York, New York 10003, 1956.

Rankin, The Man Who Rode the Thunder, Prentice-Hall, Inc., 70 5th Avenue, Englewood Cliffs, New Jersey 07632, 1960.

Rathbone, He's in the Paratroops Now, McBride Co., McBride Books, 60 Laight St., New York, New York 10013, 1943.

Reiss, Flying theAtlantic, Abelard-Schuman,Ltd., 6 West 57th Street, New York, New York 10019, 1955

Reynolds, They Fought for the Sky, Rinehart and Winston, 1957.

Rosen, The Viking Rocket Story, Harper and Row, 1955.

Serling, Electra Story, Doubleday, 1963.

Serling, The Probable Cause, Doubleday, 1960.

Smith, Robert T., Staggerwing! Maney Press, Media, Penn. 19065, 1967.

Stambler, Find a Career in Aviation, Putnam, 1960.

Tragaskis, X-15 Diary, Dutton, 1961.

U. S. Civil Aircraft, Vol. 1 ATC 1-100, Aero Pub., 1962.

U. S. Dept. of the Air Force Foundations of Air Power, U.S.Government Printing Office, Washington, D.C. 20402, 1958.

U. S. Dept. of Commerce Aircraft Powerplant Handbook, U.S.Government Printing Office, 1949.

U. S. Naval Aviation 1910-60, U.S.Navy Dept. Annapolis, Maryland, 1960.

Ulanoff, Fighter Pilot, Doubleday, 1962.

Underwood, Experimental Light Aircraft and Midget Racers, Aero Publishers,1958.

Van Sickle, Modern Airmanship, Van Nostrand, D.Co., Inc., 120 Alexander Street, Princeton, New Jersey 08540, 1961.

Williams, Conquering the Air, Nelson, Thomas and Sons, Copeland and Davis Streets, Camden, New Jersey 08103, 1930.

Zaharevitz, Walter and Jane N. Marshall, AVIATION - Where Career Opportunities Are Bright, Counselor's Guide, National Aerospace Education Council, Washington, D.C., 1964.

READING LIST

Wood, Heroes of the Air, Crowell Collier, 1946.

Zarem, New Dimensions of Flight, Dutton, 1956.

Zim, Parachutes, Harcourt, Brace and World, 1942.

Airmen and Aircraft Series, Published by J.B.Lippincott Co., East Washington Square, Philadelphia, Pennsylvania 19105, as follows:

Caidin, The Silken Angels, (History of Parachuting) 1963.

Caras, Wings of Gold, (Story of U.S.Naval Aviation) 1964.

Dwiggins, They Flew the Bendix Race, 1965.

Mason, High Flew the Falcons, (French Aces in WWI) 1964.

McClemet, Anvil of the Gods, (Airplanes Versus Storms) 1964.

Peaslee, Heritage of Valor, (The 8th Air Force in WWII) 1963.

Schamburger, Tracks Across the Sky, (Story of the U.S. Air Mail) 1963.

Shankle, The Twins of Space, (Project Gemini), 1965.

Government Publications: (Note: "Publication Order Form" (GPO) and "FAA Subscription Services" form are found on pages 255, 256, 257 and 258)

Civil Aeronautics Board (CAB). Some publications are available free, some at a single-copy charge, others on subscription only. For information and a complete listing, write to the CAB, Publications Section, B-22, Washington, D. C. 20428.

Federal Aviation Administration:

Request a complete listing of all FAA Advisory Circulars from the Dept. of Transportation, Federal Aviation Administration, Distribution Unit, TAD 484.3, Washington, D.C. 20590. Order advisory circulars with a purchase price indicated from the Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. 20402 on the order form at the end of this unit. Enclose check or money order payable to the "Superintendent of Documents" in the amounts indicated. Allow two to three months processing time at the Government Printing Office. For a complete discussion of the advisory circular structure plus procedures for being put on the mailing list for future issuances, refer to the unit on "Federal Aviation Regulations."

Airman's Information Manual --

Part 1, "Basic Flight Manual and ATC Procedures" ($4.00)
Part 2, "Airport Directory" ($4.00).
Parts 3 and 3A, "Operational Data and Notices to Airmen" ($20.00)

Airman's Information Manual (Continued)
Make check or money order payable to the "Superintendent of Documents" and send to the U.S.Government Printing Office, Washington, D.C.20402. Allow two to three months processing time at the Government Printing Office.

Federal Aviation Regulations -- Refer to the unit on "Federal Aviation Regulations" for information on the current structure and prices of individual FARs. Please note that a new issuance system began June 1969 and FARs became available by volumes on a subscription basis only. Refer to the unit on "Federal Aviation Regulations" and please address all future inquiries to the GPO.

National Aeronautics and Space Administration:
NASA non-technical publications and films are available by writing directly to the educational programs officer at the NASA Center which serves your state. (See pages 233 and 234 for list of states and addresses of the NASA offices serving them.) Some technical and scientific publications initiated by NASA are available from the Department of Commerce Clearinghouse for Technical and Scientific Information, Springfield, Virginia 22151, for $3.00 per copy.

Periodicals:

Aviation News -- Federal Aviation Administration, Superintendent of Documents, U.S. Government Printing Office, Washington, D.C.20402 - $2.00 per year for subscription.

Aviation Week and Space Technology, McGraw-Hill, 330 West 42nd Street, New York, New York 10036. $10.00 year.

Flying, Ziff-Davis Publishing Co., One Park Avenue, New York, N.Y.10016 $6.00/year.

General Aviation News, P. O. Box 3397 Van Nuys, California 91407.$3.00/yr.

The AOPA Pilot, Aircraft Owners and Pilots Association, P. O. Box 5800, Washington, D.C. 20014. $10.00/year.

American Aircraft Modeler Magazine, 733 15th St.N.W.Wash.,D.C. 20005

Sources of Assistance and Information:

A. V. Company
2795 Exposition
Denver, Colorado 80222

Aero Products Research
11811 Teale Street
Culver City, California 90230

Aviation Distributors and
Manufacturers' Assn.
1900 Arch Street
Philadelphia, Penn. 19103

Civil Air Patrol
Aerospace Education and Training
National Headquarters
Maxwell AFB, Alabama 36112

Federal Aviation Administration
Aviation Education, GA-20
800 Independence Avenue S.W.
Washington, D.C. 20590

Flying Educators
P.O.Box 3333
Van Nuys, California 91407

Jeppesen and Company
8026 East 40th Avenue
Denver, Colorado 80207

Kane Aero Company
8000 S. Lyndale Avenue
Minneapolis, Minnesota 55420

National Aerospace Education Council
Suite 310 Shoreham Building
806 15th Street N.W.
Washington, D.C. 20005

National Intercollegiate
Flying Association
University Aviation Association
Parks College - St.Louis University
East St. Louis, Illinois 62201

Sanderson Films, Inc.
P. O. Box 13121
Wichita, Kansas 67213

U. S. Department of Commerce
Clearinghouse for Federal Scientific
and Technical Information
Springfield, Virginia 22151

Recommended Memberships:

California Aerospace Education Association, P. O. Box 3244, Santa Monica, California 90403

Civil Air Patrol Aerospace Education Association, National Headquarters, Maxwell Air Force Base, Alabama 36112

National Aerospace Education Council (NAEC), 310 Shoreham Building, 806 15th Street, Washington, D.C. 20005

APPENDIX A

AERONAUTICAL SCIENCE ACTIVITIES

REACTION ENGINE

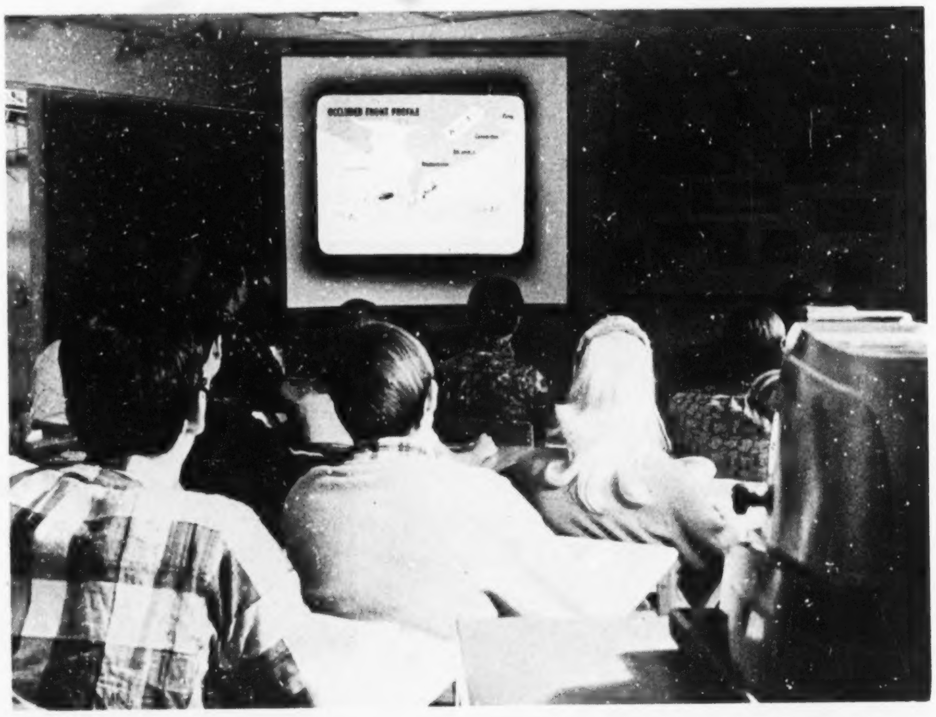
ONE OF FOUR CLASSES

AERONAUTICAL SCIENCE

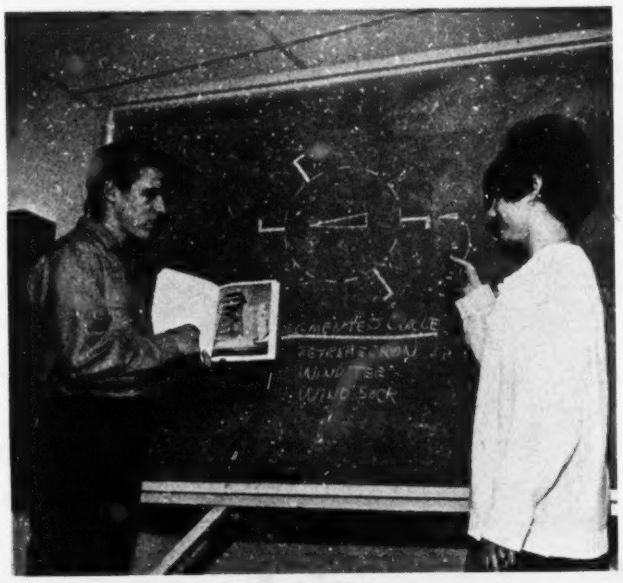
ACTIVITIES AT

REDONDO UNION

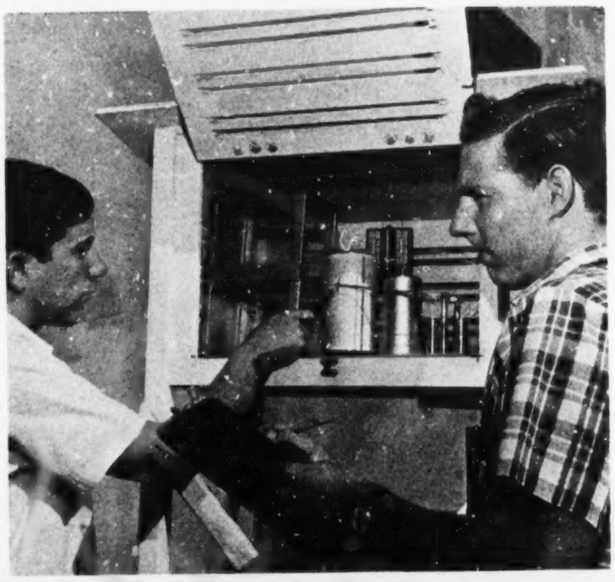
HIGH SCHOOL


OCCLUDED FRONT PROFILE

SANDERSON FILMS

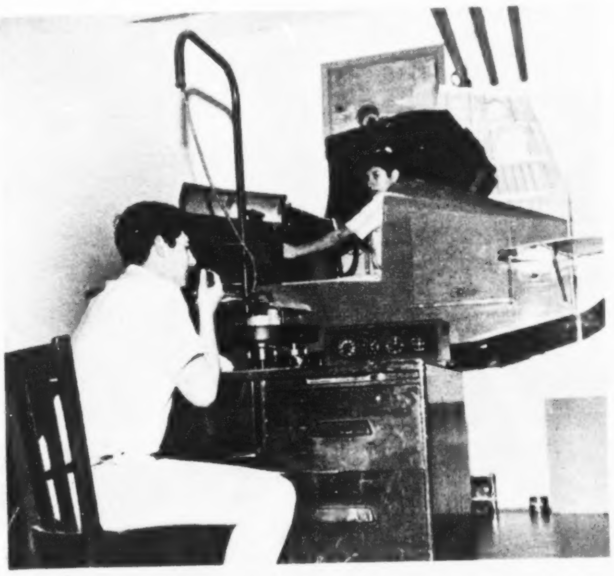

GMENTED CIRCLE
TETRAHEDRON
WIND TEE
WIND SOCK

FARs



METEOROLOGY

AERONAUTICAL SCIENCE ACTIVITIES



LINK TRAINER

POWER PLANTS

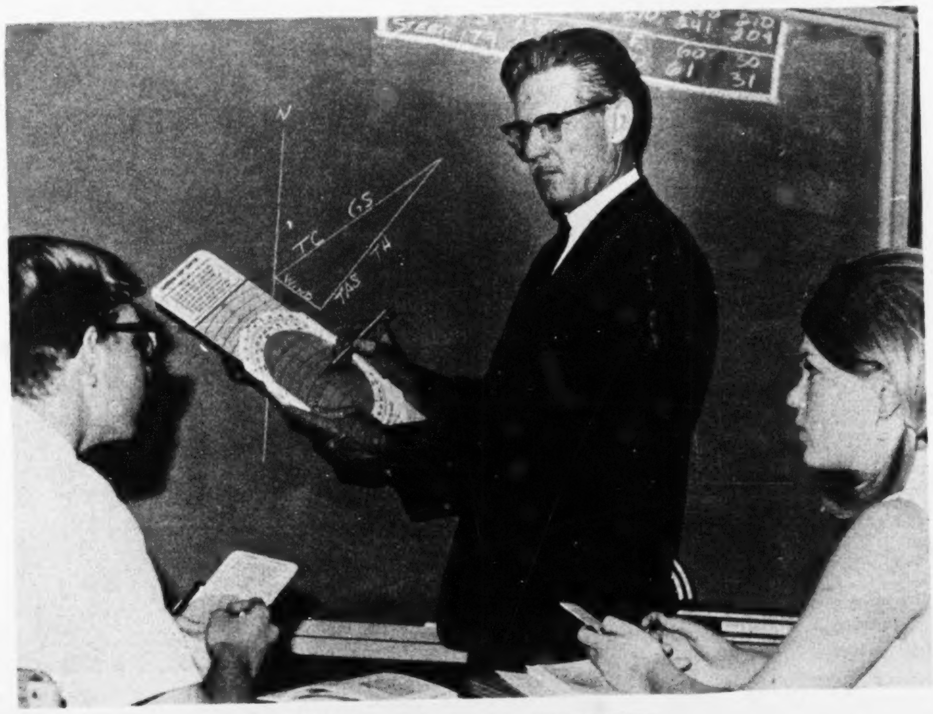
AERONAUTICAL SCIENCE

ACTIVITIES AT

REDONDO UNION

HIGH SCHOOL

HISTORY OF AVIATION

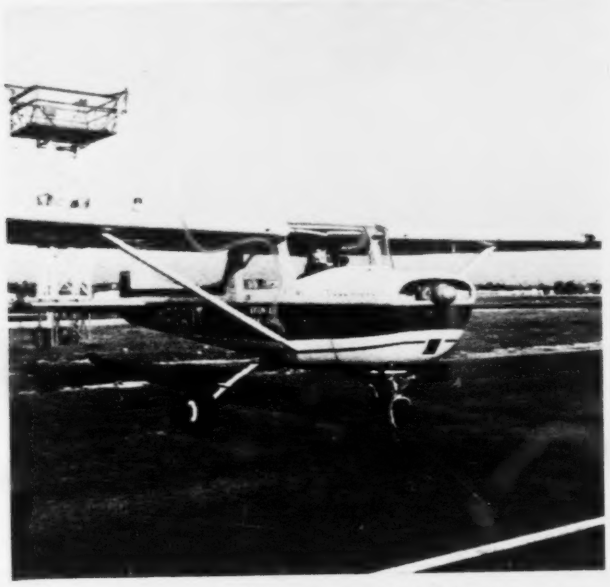


USE OF THE COMPUTER

NAVIGATION

APPENDIX A
(Cont'd)

AERONAUTICAL SCIENCE ACTIVITIES



FLIGHT TRAINING

VISIT TO THE TOWER

AERONAUTICAL SCIENCE
ACTIVITIES AT
REDONDO UNION
HIGH SCHOOL

FLIGHT INDOCTRINATION

PREPARATION FOR FLIGHT

FIELD TRIPS

APPENDIX B

FIELD TRIPS AND CAREER OPPORTUNITIES

I. Federal Aviation Administration
  A. Tower
  B. Air Route Traffic Control Center
  C. Flight Service Stations
  D. Regional Offices

II. Fixed Base Operators
  A. Flight Schools
  B. Instruction
  C. Charter & Rental

III Sales
  A. Piper
  B. Cessna
  C. Mooney
  D. Beech
  E. Used Aircraft
  F. Parts & Supplies
  G. Aircraft Materials

IV. Manufacturing
  A. Sub Assemblies
  B. Airframes
  C. Engines
  D. Engine Repair
  E. Airframe Repair
  F. Instrument
    (1) Manufacturing
    (2) Repair
  G. A& P Schools
  H. Community Colleges
    (1) A & P Colleges
    (2) Flight Schools
    (3) Stewardess Schools

V. Airlines - Major - Feeder
  A. Ticketing
  B. Meteorology
  C. Communications
  D. Schooling
  E. Ground Handling & Servicing
  F. Baggage Handling
  G. Aircraft Cleaning
  H. Repair Shop
  I. Flight Crew

VI. Agriculture
  A. Crop Dusting
    (1) Fixed Wing
    (2) Rotary Wing
    (3) Flexibility of Usage
    (4) Maintenance & Operations

APPENDIX B
(Cont'd)

FIELD TRIPS AND CAREER OPPORTUNITIES

VII. Forestry

VIII. Patrol
- A. Border
- B. Pipe Line
- C. Power Line

IX. Aerial Photography

X. Missionary Use of Aircraft

XI. Military
- A. Training - Active Duty - Reserve
  - (1) USN
  - (2) USAF
  - (3) USMC
  - (4) US Army
- B. Recruiting
- c. Flight - Ground Crew - Electronics

XII. Civil Air Patrol

XIII. Space
- A. National Aeronautics & Space Administration
- B. Research
  - (1) Universities
  - (2) U. S. Government Agencies
  - (3) Private Companies
    - a. Martin
    - b. Boeing
    - c. North American Rockwell
    - d. Lockheed
    - e. Space Technology Lab
    - f. TRW

APPENDIX C

APPPROXIMATE COSTS FOR A BASIC AND EXPANDED CLASS

Textbooks (suggested)

BASIC

An Introduction to General Aeronautics
Van Deventer - $7.00

Applied Aviation Science - Mercer $12.50

Aviation and Space in the Modern World - Bernardo - $7.95 (less 25% discount for teachers)

Fundamentals of Aviation and Space Technology - Bryan. $3.50

Aviation Weather - GPO ($4.00)

Exam-o-Grams - FAA free

Private Pilot's Handbook of Aeronautical Knowledge - GPO $2.75

Basic (Cont'd)

Aeroscience - Misenhimer - Aero Products Research, Inc., Culver City, CA 1969
Cost $10.00

EXPANDED

Ground School Workbook
Betty Hicks or equal - $5.95

Private Pilot Course (Including computer and plotter - Sanderson Films, Inc. $26.95

Private Pilot Course (without computer and plotter) Jeppesen Company $19.95

Private Pilot
Complete Programmed Course
Aero Products Research

Contact your nearest dealer or the following for discount prices:

A. V. Company
2795 E. Exposition
Denver, Colorado

Aero Products Research, Inc.
11811 Teale Street
Culver City, Calif. 90230

Jeppesen & Company
8025 E. 40th Avenue
Denver, Colorado 80207

Kane Aero Company
8000 S. Lyndale Ave.
Minneapolis, Minn. 55420

Pan American Navigation Service
12021 Ventura Blvd.
North Hollywood, Calif. 91604

Sanderson Films, Inc.
P. O. Box 13121
Wichita, Kansas 67213

- -

Navigation Equipment (suggested)

Computer Mark VIII-C	$2.00	Computer E-6B (standard size)	$10.00
Plotter Mark II	$2.00		
Charts (per student) assorted & class sets	$1.00		
(use outdated charts where possible)			

Meteorology Instruments - U.S. Gov't Surplus

A. Rain Gauge
B. Barograph
C. Thermograph approx. $100.00
D. Hygrograph
E. Anemometer

Link GAT-1 or Frasca Trainers -
U.S. Gov't. Surplus

APPENDIX C

(Cont'd)

APPROXIMATE COSTS FOR A BASIC AND EXPANDED CLASS

Flight Indoctrination

2 hours per student $12.00 per hour

Subscriptions and memberships

A. California Aerospace Education Association or other state organizations.	$6.00/yr.
B. National Aerospace Education Council	10.00/yr.
C. Aviation Week and Space Technology Magazine	10.00/yr.
D. Flying Magazine	6.00/yr.
E. General Aviation News (newspaper)	3.00/yr.
F. FAA Aviation News (Magazine)	2.00/yr.
G. American Aircraft Modeler	6.00/yr.

Supplemental Texts

$50.00

Provisions for showing free loan films

Every avenue should be explored for Flight Training opportunities for those students who are qualified, can afford it, and who earnestly desire to learn to fly.

Classroom Training Aids

A. V. Company
2795 E. Exposition
Denver, Colorado 80222

Aero Products Research, Inc.
11811 Teale Street
Culver City, Calif. 90230

Jeppesen & Company
8025 E. 40th
Denver, Colorado 80207

Kane Aero Company
8000 S. Lyndale Avenue
Minneapolis, Minnesota 55420

Sanderson Films, Inc.
P. O. Box 13121
Wichita, Kansas 67213

Government Publications

Note: A 25% discount is allowed on the purchase of 100 or more copies of publications of the same title from the Superintendent of Documents, Government Printing Office, Washington, D. C. 20402.

U.S. Government Surplus Material

A variety of useful equipment and materials, at a practically negligible cost, is available to educators through the donation program of the Office of Surplus Property Utilization, Department of Health, Education and Welfare (DHEW).

Each State, the District of Columbia, Puerto Rico and the Virgin Islands has established an agency to distribute surplus property under this program for educational purposes. Your local DHEW office will provide the name of your State Surplus Property Office.

PUBLICATION ORDER FORM

___ FAA 1.2:H 62/926-63	Federal Aviation Agency Historical Fact Book—A Chronology 1926-1963. 1966. $1.00
___ FAA 1.2:H 78	Report of the Task Force on National Aviation Goals—Project Horizon. September 1961. $1.50
___ FAA 1.2:L 86	Project Long Look—Report of the Aviation Human Resources Study Board on Manpower Requirements of the Civil Aviation Industry. September 1964. $1.00
___ FAA 1.8:F 64/963	Realm of Flight. Revised 1963. 75¢
___ FAA 1.8:F 64/2/963	Facts of Flight. Revised 1963. 50¢
___ FAA 1.8:F 64/3/963	Path of Flight. Revised 1963. 70¢
___ FAA 1.8:F 64/4	Flight Training Handbook. AC 61-21. January 1966. $1.25
___ FAA 1.8:H 36/2	Helicopter—Private and Commercial Pilot. AC 61-25. 10¢
___ FAA 1.8:In 7	Instrument Flight Instructor Written Examination Guide. AC 61-29. Revised 1966. 50¢
___ FAA 5.8/2:Ai 7/2	Personal Aircraft Inspection Handbook. AC 20-9. 1964. $1.00
___ FAA 5.8/2:C 73	Denalt Performance Computer (Fixed Pitch Propeller). Safety Education Series #8. 50¢
___ FAA 5.8/2:C 73/2	Denalt Performance Computer (Variable Pitch Propeller). Safety Education Series #8. 50¢
___ FAA 5.8/2:F 64/7	Flight Instructors Handbook. AC 61-16. 1969. $1.25
___ FAA 5.8/2:F 64/8	Flight Instructor Practical Test Guide. AC 61-14. 10¢
___ FAA 5.8/2:F 64/10	Flight Navigator Written Test Guide. AC 63–2A. 1969. 40¢
___ FAA 5.8/2:G 49/962	Basic Glider Criteria Handbook. AC 21-3. 1969. $1.00
___ FAA 5.8/2:G 99/2/966	Gyroplane—Commercial Pilot. AC 61-30. 15¢
___ FAA 5.8/2:H 36	Basic Helicopter Handbook. AC 61-13. January 1966. 75¢
___ FAA 5.8/2:In 7/966	Instrument Pilot Examination Guide. AC 61-8A. Revised 1966. 55¢

___ FAA 5.8/2:P 64/3/966	Commercial Pilot Examination Guide. AC 61-28. 1966. 75¢
___ FAA 5.8/2:P 64/4/964	Private Pilot (Airplane) Flight Training Guide. AC 61-2A. 1964. $1.00
___ FAA 5.8/2:P 64/5/965	Private Pilot's Handbook of Aeronautical Knowledge. AC 61-23. Revised 1965. $2.75
___ FAA 5.8/2:P 64/7	Pilot Transition Courses for Complex Single-Engine and Light Twin-Engine Airplanes. AC 61-9. May 1964. 15¢
___ FAA 5.8/2:P 64/9	Refresher Courses for Private and Commercial Pilots. AC 61-10. 1964. 15¢
___ FAA 5.8/2:W 37	Aviation Weather. AC 00-6. 1969. $4.00
___ FAA 7.9:D 84	Guide to Drug Hazards in Aviation Medicine. AC 91.11-1. 1962. 35¢
___ FAA 8.8:D 78	Airport Drainage. AC 150/5320-5A. 1966. 45¢
___ TD 1.1:967/pt. 1	Department of Transportation. FY 67, Part I. 65¢ The Secretary's Report to the President and the Congress.
___ TD 1.1:967/pt. 2	Department of Transportation. FY 67, Part II. 55¢
___ TD 4.2:T 27	Terrain Flying. AC 91-15. Revised 1967. 55¢
___ TD 4.8:Ai 7/6	Airframe and Powerplant Mechanics Certification Guide. AC 65-2A. Revised 1969. 65¢
___ TD 4.8:Ai 7/12	Aircraft Dispatcher Examination Written Test Guide. AC 65-4A. 1969. 50¢
___ TD 4.8:Ai 7/968	Utility Airports. AC 150/5300-4A. October 1968. $1.75
___ TD 4.8:En 3	Flight Engineer Written Test Guide. AC 63-1A. 1968. 50¢
___ TD 4.8:F 67	Forming and Operating a Flying Club. 35¢ AC 00–25
___ TD 4.8:G 91	Ground Instructor — Instrument — Written Test Guide. AC 143-2A. 1969. 70¢
___ TD 4.8:Ob 7/968	Obstruction Marking and Lighting. AC 70/7460-1. Incl. Ch. 1. 1969. 60¢
___ TD 4.8:P 21	Parachute Rigger Certification Guide—Senior Parachute Rigger, Master Parachute Rigger. 1967. 15¢ AC 65–5

___ TD 4.8:P 64	Federal Aviation Regulations Written Examination Guide. AC 61-34. 1967. 50¢
___ TD 4.8:P 64/2	Commercial Pilot—Airplane, Single-Engine. AC 61.117-1C. Revised 1968. 20¢
___ TD 4.8:P 64/3/968	Student Pilot Guide. AC 61-12B. Revised 1968. 20¢
___ TD 4.8:P 64/5	Airline Transport Pilot (Airplane) Examination Guide. AC 61-18B. Revised 1968. 55¢
___ TD 4.8:UL 8	Ultrasonic Non-Destructive Testing. AC 20-50. January 1967. 45¢
___ TD 4.8:W 27	Master Plan Report—Washington National Airport. September 1968. $4.00
___ TD 4.14:967-2	Airport Activity Statistics of Certificated Route Air Carriers. $2.75. (Issued semiannually—calendar year and fiscal year).
___ TD 4.14:968	Airport Activity Statistics of Certificated Route Air Carriers, 12 Months Ended June 30, 1968. $2.75
___ TD 4.18:967	Census of U. S. Civil Aircraft. $1.50. (Issued annually for each calendar year).
___ TD 4.18/2:969	United States Civil Aircraft Register. AC 20-6. 1969. $11.50
___ TD 4.19:968	FAA Air Traffic Activity, Fiscal Year 1968. 1968. $1.25
___ TD 4.19:968-2	FAA Air Traffic Activity. $1.75 (Issued Semi-annually—calendar year and fiscal year).
___ TD 4.20:967	FAA Statistical Handbook of Aviation. $2.75 (Issued annually for each calendar year).
___ TD 4.24:968	Standard Specifications for Construction of Airports. AC 150/5370-1A. May 1968. $3.50
___ TD 4.109:969-73	National Airport Plan. Fiscal Years 1969-1973. $1.50

___ TD 4.308:C 76	Contractions Handbook. 7340.1A. January 1, 1969. $1.00
___ TD 4.308:C 76/ch. 1	Contractions Handbook, Change I. January 14, 1969. 15¢
___ TD 4.408:G 91	Ground Instructor Examination Guide, Basic-Advanced. AC 143-1B. Revised 1967. $1.00
___ TD 4.408:H 36	Airline Transport Pilot (Helicopter) Written Test Guide. 1968. AC 61-42. 25¢
___ TD 4.408:In 7	Airplane Flight Instructor Examination Guide. AC 61-11A. Revised 1967. 60¢
___ TD 4.408:In 7/2	Instrument Pilot—Airplane. AC 61-17A. Revised 1967. 10¢
___ TD 4.8:In 7/2	Instrument Flying Handbook. AC 61-27A. 1968. $2.50
___ TD 4.408:M 91	Multiengine Airplane Class or Type Rating. AC 61-4B. Revised 1968. 15¢
___ TD 4.408:P 64	Private Pilot Written Examination Guide. AC 61-32. 1967. $1.50
___ TD 4.408:P 64/2	Private Pilot—Airplane, Single-Engine. AC 61-3B. Revised 1968. 20¢
___ 89-2:Pub Law 670	Department of Transportation Act. Public Law 89-670. October 15, 1966. 15¢
___ D 7.6/2:5A	Military Handbook, MIL-HDBK-5A—Metallic Materials & Elements for Aerospace Vehicle Structures. 1966. $4.00
___ D 7.6/2:5A/ch. 1	Change Notice 1, MIL-HDBK-5A. November 30, 1966. $1.00
___ D 7.6/2:5A/ch. 2	Change Notice 2, MIL-HDBK-5A. July 24, 1967. $1.50
___ D 7.6/2:5A/ch. 3	Change Notice 3, MIL-HDBK-5A. December 1, 1968. $1.50

MAIL ORDER FORM To:

Superintendent of Documents, Government Printing Office, Washington, D.C. 20402

Enclosed find $ .... (check, money order, or Supt. of Documents coupons).

Please send me the publications I have checked.

Name ....

Please charge this order to my Deposit Account No. ....

Street address ....

City and State .... ZIP Code ....

FOR USE OF SUPT. DOCS
.... Enclosed ....
.... To be mailed later ....
.... Subscription ....
Refund ....
Coupon refund .....
Postage ....

FOR PROMPT SHIPMENT, PLEASE PRINT OR TYPE ADDRESS ON LABEL BELOW INCLUDING YOUR ZIP CODE

U.S. GOVERNMENT PRINTING OFFICE
DIVISION OF PUBLIC DOCUMENTS
WASHINGTON, D.C. 20402

OFFICIAL BUSINESS

RETURN AFTER 5 DAYS

POSTAGE AND FEES PAID
U.S. GOVERNMENT PRINTING OFFICE

Name ....

Street address ....

City and State .... ZIP Code ....

FAA SUBSCRIPTION SERVICES

______ FAA 5.12:965 (SSTC)	SUMMARY OF SUPPLEMENTAL TYPE CERTIFICATES. Nov. 1965. *$9.00 domestic; $3.50 additional for foreign mailing.*
______ FAA 5.15:965 (AIR)	Acceptable Methods, Techniques and Practices: AIRCRAFT INSPECTION AND REPAIR. 1965. AC 43.13-1. *$3.00 domestic; $1.00 additional for foreign mailing.*
______ FAA 5.16:965 (AALT)	AIRCRAFT ALTERATIONS. 1965. AC 43.13-2. *$2.00 domestic; 50¢ additional for foreign mailing.*
TD 4.9: (AVN)	FAA AVIATION NEWS. Issued Monthly. *$2.00 a year domestic; 50¢ additional for foreign mailing.* ____ one ____ two or ____ three years
______ TD 4.10/2:969 (ADS-1)	Summary of Airworthiness Directives: VOLUME 1, SMALL AIRCRAFT. Jan. 1969. *$7.25 domestic; $1.50 additional for foreign mailing.*
______ TD 4.10/3:967 (ADL-2)	VOLUME 2, LARGE AIRCRAFT. Jan. 1967. *$6.00 domestic; $1.25 additional for foreign mailing.*
TD 4.11: (IN)	INTERNATIONAL NOTAMS. Issued Weekly. *$5.00 a year domestic; $2.25 additional for foreign mailing.* ____ one ____ two or ____ three years
______ TD 4.12:Pt 1/ (BFAP)	Airman's Information Manual: PART 1—BASIC FLIGHT MANUAL AND ATC PROCEDURES. Issued Quarterly. *$2.50 a year domestic; 75¢ additional for foreign mailing (subscription accepted for one year only).*
______ TD 4.12:Pt 2/ (ADP)	PART 2—AIRPORT DIRECTORY. Issued semiannually. *$4.00 a year domestic; $1.00 additional for foreign mailing (subscription accepted for one year only).*
______ TD 4.12:Pt 3/ (ODNA)	PART 3—OPERATIONAL DATA AND NOTICES TO AIRMEN. Issued Biweekly. *$18.00 a year domestic; $5.00 additional for foreign mailing (subscription accepted for one year only).*

______ TD 4.15:967 (AS)	AIRCRAFT TYPE CERTIFICATE DATA SHEETS AND SPECIFICATIONS. Reprinted April 1967. *$20.00 domestic; $5.00 additional for foreign mailing.*
______ TD 4.15/2:968 (EPS)	AIRCRAFT ENGINE AND PROPELLER TYPE CERTIFICATE DATA SHEETS AND SPECIFICATIONS. Reprinted 1968. *$16.00 domestic; $4.00 additional for foreign mailing.*
______ TD 4.308:F 64 (FSH)	FLIGHT SERVICES, 7110.10. April 1, 1969. *$9.00 domestic; $2.50 additional for foreign mailing.*
______ TD 4.309:17 (IFIM)	INTERNATIONAL FLIGHT INFORMATION MANUAL. Vol. 17, April 1969. *$3.00 domestic; 75¢ additional for foreign mailing.*
______ TD 4.310: (LOID)	LOCATION IDENTIFIERS, 7350.1. Issued 3 times a year. *$6.00 a year domestic; $1.25 additional for foreign mailing (subscription accepted for one year only).*
______ TD 4.409:968 (GAIS)	GENERAL AVIATION INSPECTION AIDS SUMMARY. August 1968. AC 20-7F. *$3.00 domestic; 75¢ additional for foreign mailing.*

TO INSURE EXPEDITIOUS HANDLING OF YOUR ORDER
DO NOT INCLUDE REQUEST FOR OTHER PUBLICATIONS ON THIS FORM

NAME ....
ADDRESS ....
CITY, STATE, ZIP CODE ....

FOR USE OF SUPT. DOCS.	

MAIL ORDER FORM WITH REMITTANCE TO: SUPERINTENDENT OF DOCUMENTS, GOVERNMENT PRINTING OFFICE, WASHINGTON, D.C. 20402

Enclosed find $ .... (check, money order, or Supt. of Docs. Coupons) for the services I have indicated above.

FOR USE OF SUPT. DOCS.

☆ U. S. GOVERNMENT PRINTING OFFICE : 1969 O - 368-941